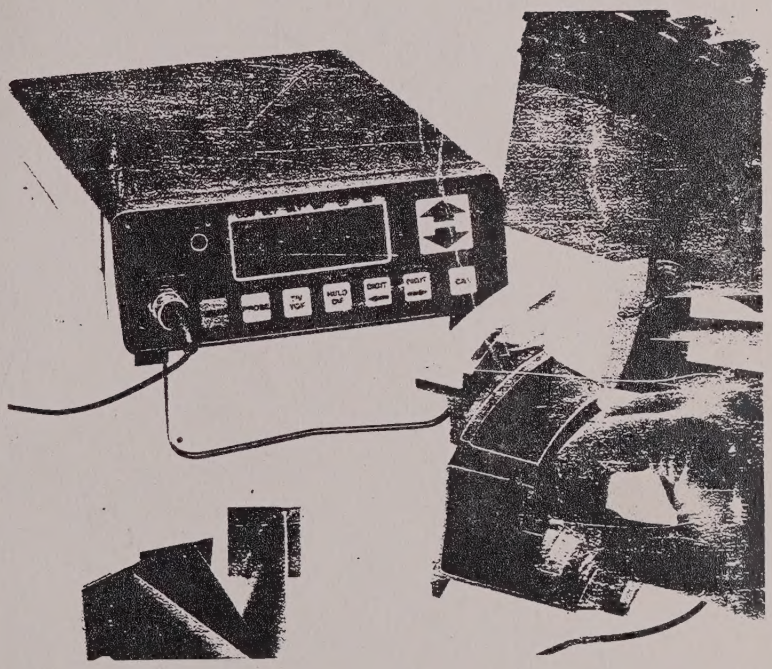
Krautkramer Branson



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CL304

Operating Manual

Important Notice

The following information must be read and understood by any user of a Krautkramer Branson ultrasonic thickness gauge. Failure to follow these instructions can lead to errors in thickness measurements or other test results. Decisions based on erroneous results can, in turn, lead to property damage, personal injury or death.

General Warnings

Proper use of ultrasonic test equipment requires three essential elements:

- Selection of the correct test equipment
- Knowledge of the specific "test application requirements"
- Training on the part of the instrument operator

This operating manual provides instruction in the basic set-up and operation of the KB thickness gauge. There are, however, additional factors which affect the use of ultrasonic test equipment. Specific information regarding these additional factors is beyond the scope of this manual. The operator should refer to text-books on the subject of ultrasonic testing for more detailed information.

Operator Training

Operators must receive adequate training before using ultrasonic test equipment. Operators must be trained in general ultrasonic testing procedures and in the set-up and performance required by a particular test. Operators must understand:

- Soundwave propagation theory
- Effects of the velocity of sound of the test material
- Behavior of the sound wave where two different materials are in contact
- Areas covered by the sound beam

More specific information about operator training, qualification, certification and test specifications is available from various technical societies, industry groups, and government agencies

Testing Limitations

In ultrasonic testing, information is obtained only from within the limits of the sound beam. Operators must exercise great caution in making inferences about the test material outside the limits of the sound beam. For example, when testing large materials it may be impossible or impractical to inspect the entire test piece. When a less-than-complete inspection is to be performed, the operator must be shown the specific areas to inspect. Inferences about the condition of areas not inspected,

based on data from the evaluated areas, should only be attempted by personnel fully trained in applicable statistical and probability techniques. In particular, materials subject to corrosion or erosion, in which conditions can vary significantly in any given area, should be evaluated only by fully trained and experienced operators.

Sound beams reflect from the first interior surface encountered. Because of part geometry and overlapped flaws or overlapped surfaces, thickness gauges may measure the distance to an internal flaw rather than to the back wall of the material. Operators must take steps to ensure that the entire thickness of the test material is being examined.

Ultrasonic Thickness Measurement Critical Operating Procedures

The following operating procedures must be observed by all users of ultrasonic thickness gauges in order to minimize errors in test results.

1. *Calibration of Sound Velocity*
The principle of operation of an ultrasonic thickness gauge is that the instrument measures the time of flight of an ultrasonic pulse through the test piece and multiplies this time by the velocity of sound in the material. Thickness measuring error is minimized by ensuring that the sound velocity to which the instrument is calibrated is the sound velocity of the material being tested. Actual sound velocities in materials often vary significantly from the values found in published tables. In all cases, best results are obtained if the instrument is calibrated on a velocity reference block made from the same material as the test piece; this block should be flat and smooth and as thick as the maximum thickness of the test piece.

Operators should also be aware that sound velocity may not be constant in the material being tested; heat treating, for example, can cause significant changes in sound velocity. This must be considered when evaluating the accuracy of the thickness provided by this instrument. Instruments should always be calibrated before testing, and the calibration should be checked after testing, to minimize testing errors.

2. *Probe Zero Procedure*
The probe zero procedure must be performed as described in this manual. The probe zero block should be clean and in good condition, without noticeable wear. Failure to properly perform the probe zero procedure will result in inaccurate thickness readings.

3. *Effects of Temperature on Calibration*
Variations in temperature change the

sound velocity of materials and transducer delay lines and, therefore, zero calibrations. All calibrations should be performed on-site, and with test blocks at the same temperature as the test piece, in order to minimize errors due to temperature variations.

4. *Transducer Selection*
The transducer used in testing must be in good condition without noticeable wear of the front surface. Badly worn transducers will have a reduced effective measuring range. The specified range of the transducer must include the complete range of thicknesses to be tested. The temperature of the material to be tested must be within the transducer's temperature range.

5. *Use of Couplants*
Operators must be familiar with the use of ultrasonic couplants. Testing skills must be developed so that couplant is used and applied in a consistent manner to minimize variations in couplant layer thickness and errors in test results. Calibration and actual testing should be performed under similar coupling conditions, using a minimum amount of couplant and applying consistent pressure on the transducer.

6. *Doubling*
Ultrasonic thickness gauges will, under certain conditions, display readings which are twice (or, in some cases, three times) the actual material thickness being measured. This effect, commonly known as "doubling," can occur below the minimum specified range of the transducer. If the transducer being used is worn, doubling is possible at thicknesses greater than the minimum specified range.

When using a new transducer, any reading which is less than twice the minimum specified range of the transducer may be a "doubled" reading, and the thickness of the material being tested should be verified by the use of other methods. If the transducer shows any sign of wear, doubling may occur at a thickness greater than twice the minimum specified range. This thickness should be determined by calibrating the instrument/transducer combination on reference blocks that represent the complete range of possible thicknesses that may be encountered in testing. This is particularly important when the test piece is being ultrasonically measured for the first time or in any case where the history of thickness of the test specimen is unknown.

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Warranty

When used in accordance with the manufacturer's written instructions and under normal operating conditions, Krautkramer Branson's (KB) test instruments are guaranteed to be free from defects in material and workmanship for a period of one (1) year from date of shipment. KB will repair free of labor and material charges any unit which proves defective within one year from date of original shipment by KB or by an authorized representative or distributor.

All repair work will be made F.O.B Lewistown, Pennsylvania, or at an authorized repair station as advised by KB, provided the defective unit is returned properly packed with all transportation charges prepaid. Any and all equipment replacement will be at the sole discretion of KB.

This warranty shall not apply to equipment subjected to misuse or abuse, improper installation, alteration, neglect, or accident. Excluded from this warranty coverage are expendable items such as transducers, interconnecting cables, batteries, and vacuum tubes when used in the instrument. Accessory items such as recorders, etc. will be covered under the original manufacturer's warranty as given to KB.

This warranty is limited to the original purchaser and is not transferrable. No other warranty, expressed or implied, is made.

Service

Every effort has been made to provide you with a reliable product. However, should service become necessary, KB has established a number of Authorized Service Centers. For the location of the nearest facility, contact:

Manager of Customer Service
Krautkramer Branson
Mifflin County Industrial Park
P.O. Box 350
Lewistown, PA 17044
Telephone: 717-242-0327
717-242-0331
Telex: 842-354
Telefax: 717-242-2606

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Important Notice

Read the following information prior to use of any Krautkramer Branson instrument. A failure to read and understand the following information will cause errors to occur during use of the instrument. Such errors may, in turn, lead to property damage or personal injury.

General Warnings

Proper use of ultrasonic test equipment requires three essential elements:

- Selection of the correct test equipment.
- Knowledge of the specific "test application requirements".
- Training on the part of the instrument operator.

This operating manual provides instruction in the basic set-up and operation of the CL304 thickness gauge. There are, however, additional elements which affect the use of ultrasonic test equipment. Specific information regarding these additional elements is beyond the scope of this manual. The operator should refer to textbooks on the subject of ultrasonic testing for more detailed information.

Operator Training

Operators must receive adequate training before using ultrasonic test equipment. Operators must be trained in general ultrasonic testing procedures and in the set-up and performance required by a particular test. Operators must understand:

- Soundwave propagation theory.
- Effects of the velocity of sound in the test material.
- Behavior of the sound wave where two different materials are in contact.
- Areas covered by the sound beam.

If the operator lacks this basic knowledge, the operator may receive and rely upon incorrect data. Property damage or personal injury may result. More specific information about operator training, qualification and certification is available in ASNT-TCIA and in many other industry specifications.

Test Requirements

Every ultrasonic test has certain test application requirements. These include:

- Determination of what is to be tested.
- Selection of a suitable test technique.
- Evaluation of test material conditions.
- Selection of acceptance/ rejection limits.

Prior to testing, those responsible for the product must inform the operators of the test application requirements. Previous experience with the test material is the best basis for determining test application requirements. Additional information concerning test specifications and

prodcedures is available from various Technical Societies, Industry Groups, and Government Agencies.

Testing Limitations

In ultrasonic testing, information is obtained only from within the limits of the sound beam. Operators must exercise great caution in making inferences about the test material outside the limits of the sound beam. For example, when testing large material it may be impossible or impractical for the operator to perform a complete, one hundred percent inspection. When less than a complete inspection is to be performed, the operator must be shown the specific areas to inspect. When data from these areas are evaluated, qualified quality assurance personnel may use statistical and probability techniques to make inferences about areas not inspected.

Sound beams reflect from the first interior surface encountered. Because of part geometry and overlapped flaws or overlapped surfaces, reflections from hidden flaws or surfaces may go undetected. Operators must take steps to assure that the entire thickness of the test material is being examined.

Ultrasonic Thickness Measurements Warnings

Ultrasonic thickness measurement is the mathematical result of multiplying the velocity of sound in a material by the transit time of the sound waves traveling through the material. Prior to use, the instrument is calibrated to the material's sound velocity. The instrument measures the transit time and displays a thickness value by multiplying this transit time by the sound velocity.

Velocity of Sound

Accurate ultrasonic thickness measurement depends upon the velocity of sound in the material. The velocity of sound varies because of characteristics of the test material. Velocity is not affected by the test instrument. Before testing begins, the operator must calibrate the instrument to the velocity of sound of the test material. The manual describes how to calibrate the instrument when the velocity of sound is known. If the velocity of sound is not known, the instrument can still be calibrated if a sample of the test material of known thickness is available. Ultrasonic instruments work by assuming that the velocity of sound is uniform in the test material. Sometimes, however, the test material's velocity of sound is not uniform. The instrument should, therefore, be recalibrated from time to time to check that the velocity of sound of different tested parts is the

same. If the instrument is not recalibrated, the operator may receive erroneous measurements which could result in property damage or personal injury.

Temperature Dependence

Velocity of sound in the test material is affected by the material's temperature. When testing a material subject to different temperatures, the operator should frequently recalibrate the instrument using a sample at the test temperature. Temperature difference can also affect the probe delay line and the instrument itself. Frequent recalibration of the test instrument at the test temperature will reduce errors caused by temperature variations.

Testing Corroded Areas

Ultrasonic testing of materials subject to corrosion, erosion, and pitting requires special attention. Operators should consider both previous experience and calculations for determining highly corrosive areas so as to achieve the most error free results.

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1.0 Introduction

1.1 Foreward

The CL304 is a battery/AC powered ultrasonic thickness gauge designed for portable or benchtop use. The CL304 is a multiple purpose gauge for measuring the thickness of a wide variety of fabricated parts, especially when part geometry or other considerations allow access to only one side of the part.

Features of the CL304:

- Push button probe zero fascilitates calibration when using contact type probes.
- Differential operating mode displays the difference between the measured thickness and a user selectable nominal value.
- Thickness, material velocity, or time of flight display.
- Hi/Lo set points with alarm outputs fascilitates tolerance checks.
- Auto-ranging or selectable displayed resolution.
- RF signal output jack allows echo waveforms to be displayed on an oscilloscope for critical testing applications.
- Automatic display backlighting.
- Accepts, without modification, optional data interfaces, e.g. RS232, SPC.
- Programmable TGC, gain levels, blocking delays, and pulse repitition rate for maximum applications flexibility.
- Compatible with "bubbler" or "squirter" type probes for special measurement situations.

1.2 How the CL304 Measures Thickness

The CL304 operates on the pulse/echo principle similar to sonar. Depending on the thickness of the part to be measured, the CL304 can employ one of two measuring techniques: **contact** or **delay.**

In the contact mode, generally used for parts≥.060" (1.5mm) thick, a short ultrasonic pulse is transmitted into the part by a probe (transducer). This pulse travels through the part until it reaches the back surface, where it is reflected back to the probe. The time needed for the ultrasonic pulse to make the round trip through the part is divided by two and multiplied by the velocity of sound in the test material to determine the thickness of the part. Reference Figure 1.

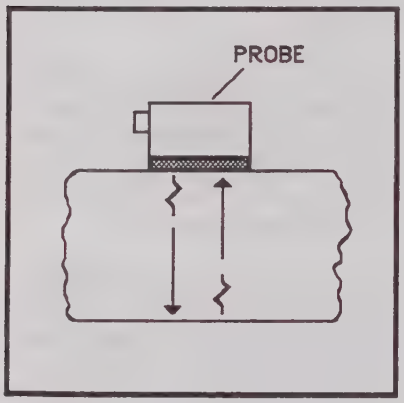


Figure 1

For measuring thin parts, ≤ .060" (1.5mm), it is necessary to use the CL304 in the delay mode. The delay mode uses a special delay probe which includes a delay line between the probe and the part to be measured. The transit time measurement begins with the interface echo, which is the echo caused by part of the ultrasonic pulse being reflected at the interface between the delay line and the part being measured. Depending on part thickness, the CL304 will automatically choose whether to measure from the interface echo to the first backwall echo, known as interface to first mode, or from the one backwall echo to the next backwall echo known as multi-echo mode. Refence Figure 2.

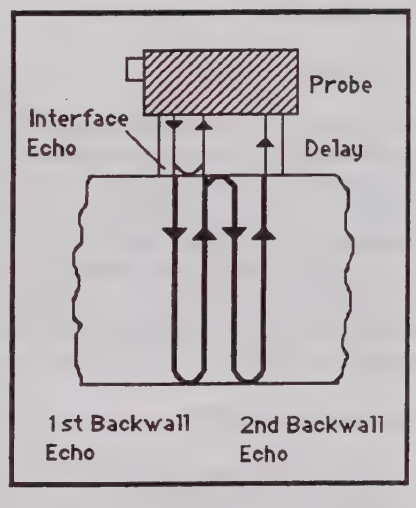


Figure 2

2.1 Battery Installation

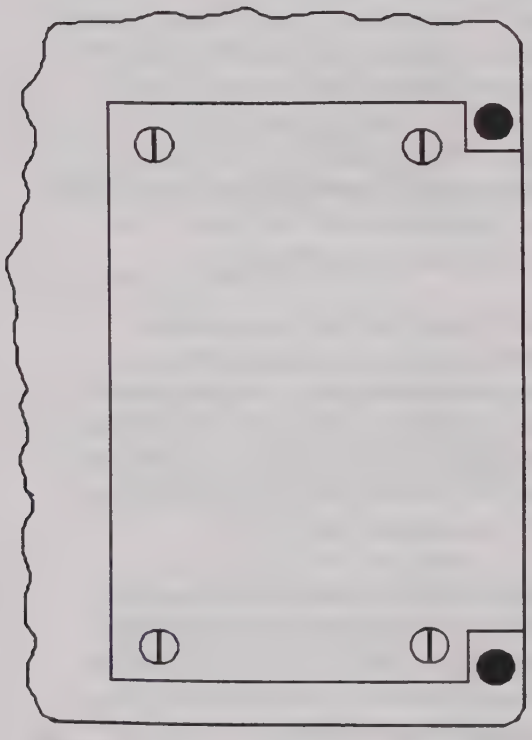


Figure 3

The Krautkramer Branson CL304 Precision Ultrasonic Thickness Gauge is designed to operate on four "D" size rechargeable NiC-ad batteries, standard alkaline cells, or line current using the battery charger/battery eliminator.

The CL304 battery compartment is located on the bottom of the instrument. To install batteries in the unit, carefully loosen the four quarter-turn fasteners securing the battery compartment cover. See figure 3. Remove the battery compartment cover, exposing the battery compartment.

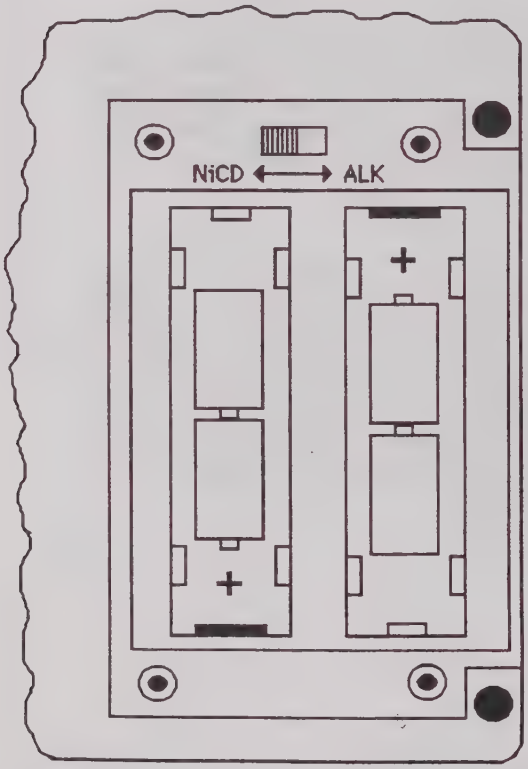
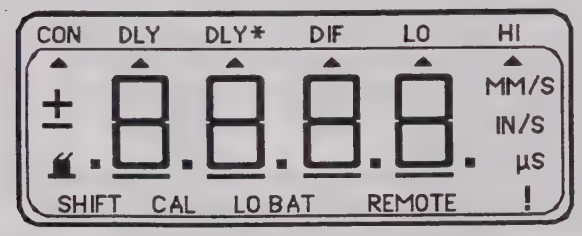


Figure 4

Install four "D" size Nicad or alkaline batteries noting the polarity as marked inside the battery compartment. Reference figure 4. The CL304 is protected against accidental reversal of battery polarity. If the batteries are installed with the polarity reversed, no damage to the instrument will occur, but the instrument will not operate.

Important: Note the two position slide switch at the top of the battery compartment. It is critical that this switch be set in the correct position for the type of batteries being installed. If this switch is not set correctly and the battery charger is used, damage to the instrument may result.

The CL304 may be operated without batteries by using the battery charger/battery eliminator. The slide switch should be set in the NiCad position if the instrument is to be operated in this manner.



2.2 Display Symbols

CON ▲ — A carat lit under **CON** indicates that the CL304 is in the contact operating mode.

DLY ▲ — A carat lit under **DLY** indicates that the CL304 is in the delay (interface start) operating mode.

DLY* ▲ — A carat lit under **DLY*** indicates that the CL304 is in the special operating mode. This operating mode is for use with the Krautkramer Branson plastics probe.

DIF ▲ — A carat lit under **DIF** indicates that the instrument is in the differential operating mode.

LO ▲ — A carat lit under **LO** indicates that the low limit value is being displayed.

HI ▲ — A carat lit under **HI** indicates that the high limit value is being displayed.

± — The ± annunciator is used in the differential operating mode to indicate whether the displayed value is positive or negative relative to the differential offset value.

The coupling indicator lights when adequate acoutical coupling between the probe and the test piece has been achieved.

SHIFT — The **SHIFT** annunciator lights when the **SHIFT** key is pressed, indicating that the shifted functions (printed in blue) are accessible.

CAL — The **CAL** annunciator lights when the **CAL** key is pressed, indicating that thickness or velocity calibration values, differential offset, low limit, or high limit may be entered via the scrolling keys.

LO BAT The **LO BAT** annunciator lights when approximately 20 minutes of battery life remain.

The digit select annunciator bar lights when the CL304 is in the CAL mode. It indicates which digit is under active control of the scrolling keys. The digit select bar may be moved to the right or left by pressing the **DIGIT** keys.

REMOTE The **REMOTE** annunciator lights when the instrument settings are under the control of a remote terminal via the interface port. The keyboard controls are disabled when the REMOTE annunciator is lit.

! The **!** annunciator lights when the CL304 is operating from one of the user programmable memory banks.

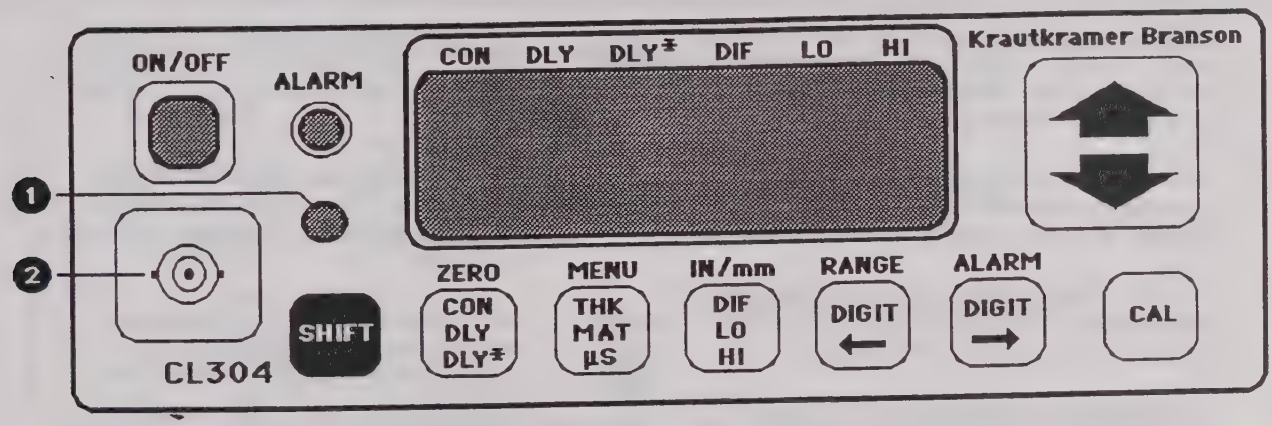
mm/s The **mm/s** annunciator indicates that the displayed value is a material velocity and the units of measurement are millimeters per second.

IN/s The **IN/s** annunciator indicates that the displayed value is a material velocity and the units of measurement are inches per second.

µs The **µs** annunciator indicates that the displayed value is a time of flight and the units of measurement are microseconds.

mm The **mm** annunciator indicates that the displayed value is a material thickness and the units of measurement are millimeters.

IN The **IN** annunciator indicates that the displayed value is a material thickness and the units of measurement are inches.



2.3 Keyboard Controls

ON/OFF The **ON/OFF** switch turns the instrument on and off.

SHIFT The **SHIFT** key permits the shifted functions (ZERO, MENU, IN/mm, RANGE, ALARM) to be accessed.

CON
DLY
DLY* The **CON/DLY/DLY*** or **PROBE** key is used to select whether the CL304 is to operate in the contact mode, delay mode, or special (plastics) mode.

THK
MAT
µS The **THK/MAT/µS** key is used to select whether the displayed value is a material thickness, material velocity, or time of flight.

DIF
LO
HI The **DIF/LO/HI** key is used to select the differential operating mode, or low limit and high limit functions.

DIGIT
← → The **DIGIT** keys are used to select the display digit under active control of the scrolling keys.

2.0 Operation

CAL The **CAL** key is used to activate the scrolling keys so that thickness or material velocity calibration values, differential offset, low limit, or high limit values can be entered.

ZERO The **ZERO** key is used to perform a probe zero adjustment when using contact type probes. ZERO is a shifted function.

MENU The **MENU** key is used to access the special menu functions. Refer to Section 3.0 of this manual. MENU is a shifted function.

IN/mm The **IN/mm** key selects the units of the displayed value, either inches or millimeters. IN/mm is a shifted function.

RANGE The **RANGE** key is used to manually select the displayed resolution in the thickness measuring mode. RANGE is a shifted function.

ALARM The **ALARM** key is used to enable/disable the high/low limit alarm signal. ALARM is a shifted function.

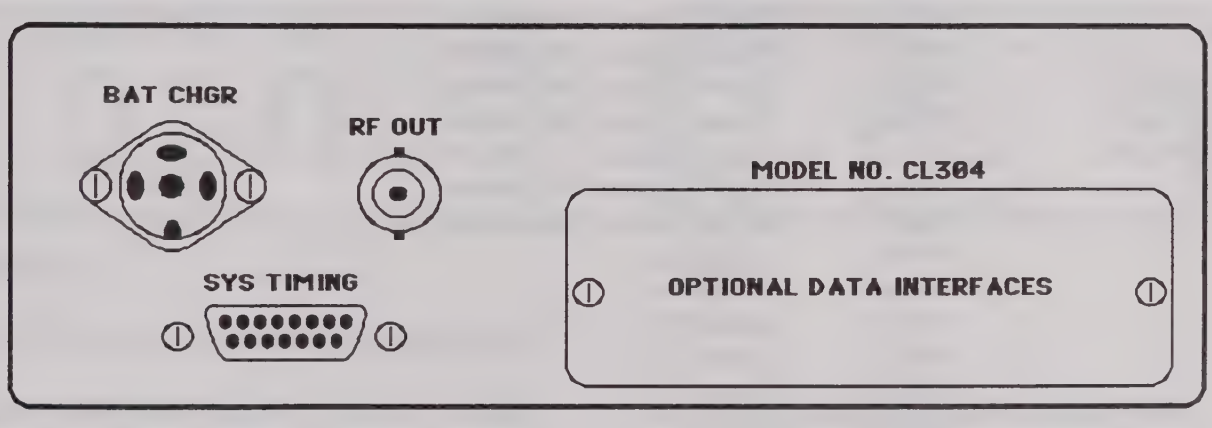
The **Scroll Up** key increases the displayed value. The instrument must be in the CAL mode for the scroll up key to be functional.

The **Scroll Down** key decreases the displayed value. The instrument must be in the CAL mode for the scroll down key to be functional.

The LED **ALARM** indicator is operational when the low and/or high limit is set. If a measured thickness exceeds either limit, the LED will glow red. If the measured thickness is within the set limits the LED will glow green.

Photo cell automatically activates the display backlight when the ambient light level is insufficient to read the display easily.

Probe connector.

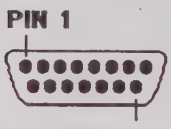


2.4 Rear Panel Connectors

BAT CHGR Connector for the battery charger/battery eliminator.

RF OUT BNC connector allows the RF waveforms to be viewed on an oscilloscope as an aid in verifying thickness readings when the front surface and/or backwall is rough or non-parallel. Also used when setting up one of the special menu files.

SYS TIMING This DB-15 connector carries a number of system timing and other signals, making it unnecessary to open the instrument housing to access them for special test requirements. These signals are listed on the next page.



PIN 1	Signal ground reference
PIN 2	Signal ground reference
PIN 3	Signal ground reference
PIN 4	Signal ground reference
PIN 5	Signal ground reference
PIN 6	Signal ground reference
PIN 7	Signal ground reference
PIN 8	+5VDC
PIN 9	Pulser fire
PIN 10	Select A
PIN 11	Select B
PIN 12	Select C
PIN 13	Alarm 1
PIN 14	Alarm 2
PIN 15	Selected signal, reference Appendix A

OPTIONAL DATA INTERFACES

The standard CL304 is equipped with an expansion slot which accepts various optional data interface circuit boards. Interface options include RS232 and SPC. Contact Krautkramer Branson for more information concerning available interfaces.

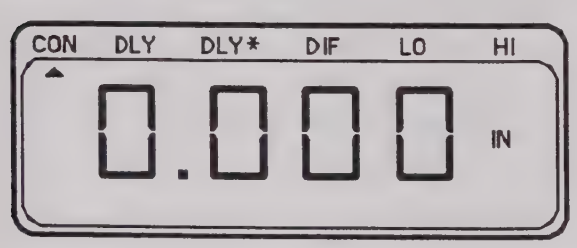


Figure 5

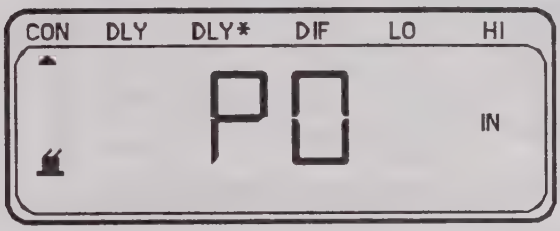


Figure 6

2.5 Probe Zero Procedure—Contact Mode

With the CL304 switched on and a contact probe connected, press the **CON/DLY/DLY*** or **PROBE** key until the carat lights under **CON** in the menu. The display should appear as in figure 5. The displayed units should be IN or mm. If the displayed units are in/s, mm/s, or µs, press the **THK/MAT/µS** key until IN or mm is displayed.

Before calibrating the instrument in the contact mode, it is necessary to perform a probe zero adjustment. This zero adjustment compensates for the thickness of the wear plate on the front of a contact style probe and should always be performed before using the CL304 in the contact mode.

NOTE: The zero adjustment must be done with the zero reference block supplied with the instrument, or with a block which has been specially calibrated for this purpose. Refer to Appendix B for details on how to calibrate a new zero reference block.

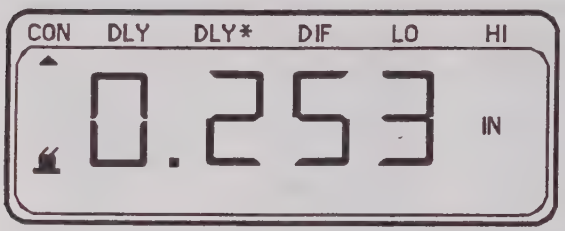


Figure 7

Apply a small amount of couplant to the zero reference block supplied with the CL304 and couple the probe to it. While keeping the probe coupled to block, note the coupling indicator is lit, press the **SHIFT** key then the **ZERO** key. The display will appear as in figure 6.

Continue to keep the probe coupled to the zero block. After a few seconds, a thickness value will be displayed as in figure 7. The CL304 is now ready for calibration.

NOTE: After performing the probe zero procedure, your instrument may not display the same value shown in figure 7. This is normal and does *not* indicate an instrument malfunction.

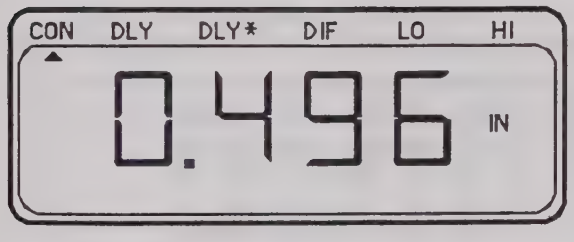


Figure 8

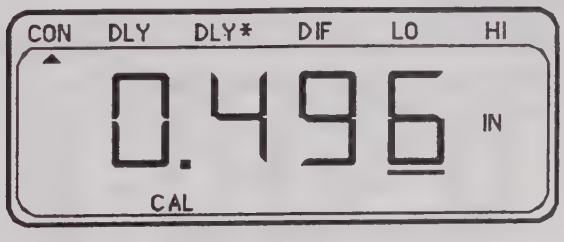


Figure 9

2.6 Calibration to a Known Thickness—Contact Mode

Perform the probe zero procedure described in section 2.5. Select the desired units of measurement, either inches or millimeters, by pressing the **SHIFT** key followed by the **IN/mm** key. Apply a small amount of couplant to a calibration standard (of the same material and velocity as the material to be measured) of known thickness, e.g. 0.500 inch, and couple the probe to it. For best results the calibration standard should be close to the thickness of the parts to be measured.

When a stable reading is obtained, remove the probe from the calibration standard. Reference figure 8.

Press the **CAL** key. The display will appear as in figure 9.

Figure 10

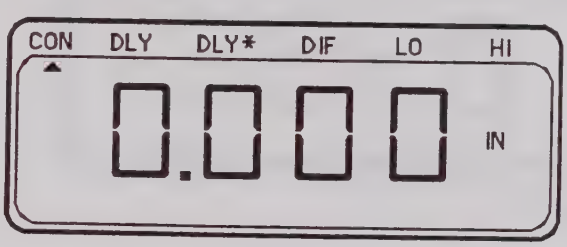


Figure 11

Use the **SCROLLING** keys to adjust the displayed thickness to the correct value. Reference figure 10. Note that the digit select bar appears under the digit which is under active control of the scrolling keys. You may change the position of the digit select bar by using one of the **DIGIT** keys. This function can speed up the calibration procedure when it is necessary to make large changes in the displayed value. After the correct thickness value is displayed, press the **CAL** key again to take the instrument out of the calibration mode. The display will appear as in figure 11. The CL304 is now calibrated and ready to measure test pieces of the same material and velocity as the calibration standard.

For future reference, the material velocity of the calibration standard may be viewed by pressing the **THK/MAT/μS** key once. To return to the thickness measuring mode, press the **THK/MAT/μS** key twice.

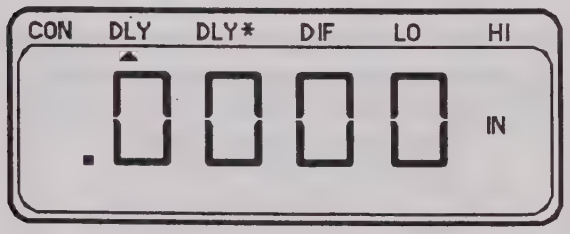


Figure 12

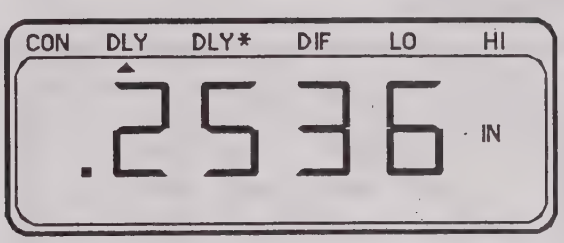


Figure 13

2.7 Calibration to a Known Thickness—Delay/Immersion Mode

Switch the instrument on and connect a delay or immersion type probe. Use the **PROBE** key to put the instrument in the delay mode. The carat should be lit under **DLY** in the menu. Select the desired units of measurement, either inches or millimeters, by pressing the **SHIFT** key followed by the **IN/mm** key. The display will appear as in figure 12.

Couple the probe to a calibration standard (of the same material and velocity as the material to be measured) of known thickness, e.g. .2500 inch. For best results the calibration standard should be close to the thickness of the parts to be measured. When a stable reading is obtained, remove the probe from the calibration standard. Reference figure 13.

NOTE: The probe zero procedure is not required for delay/immersion mode.

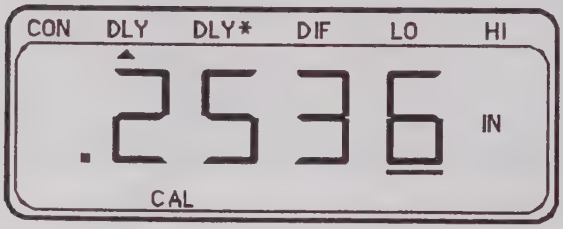


Figure 14

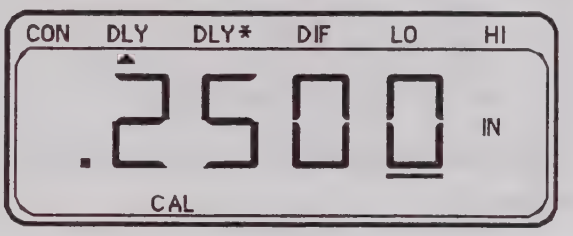


Figure 15

Press the **CAL** key. The display will appear as in figure 14.

Use the **SCROLLING** keys to adjust the displayed thickness to the correct value. Reference figure 15. Note that the digit select bar lights under the digit which is under the active control of the scrolling keys. You may change the position of the digit select bar by using one of the **DIGIT** keys. This function can speed up the calibration procedure when it is necessary to make large changes to the displayed value.

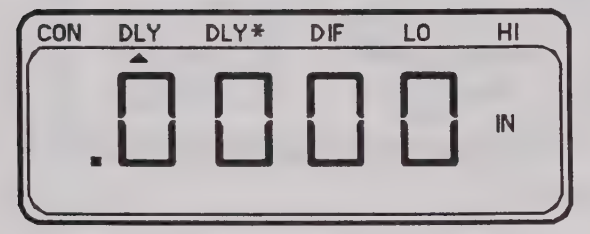


Figure 16

After the correct thickness value is displayed, press the **CAL** key again to take the instrument out of the calibration mode. The display will appear as in figure 16. The CL304 is now calibrated and ready to measure test pieces of the same material and velocity as the calibration standard.

For future reference, the material velocity of the calibration standard may be viewed by pressing the **THK/MAT/μS** key once. To return to the thickness measuring mode, press the **THK/MAT/μS** key twice.

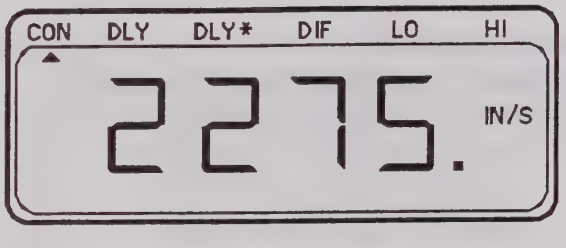


Figure 17

2.8 Calibration to a Known Velocity—Inch Format

The CL304 may also be calibrated to a known material velocity. In the inch format the velocity range is 10,000 to 800,000 in/μs. The material velocity value is displayed as XXXX. IN/μs where the implied muliplier is 10^2.

To calibrate the CL304 to a known velocity, switch the instrument on and connect the desired probe. Use the **PROBE** key to put the CL304 into the proper operating mode. If a contact probe is used, perform the probe zero procedure described in section 2.5. Select the desired units of measurement, either inches or millimeters, by pressing the **SHIFT** key followed by the **IN/mm** key. Use the **THK/MAT/μS** key to change the displayed value to material velocity (in/μs). The display will show the velocity value currently set in the instrument. Reference figure 17 as an example.

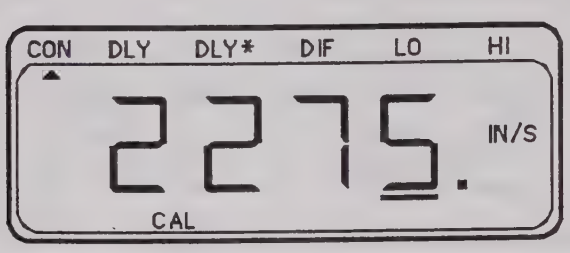


Figure 18

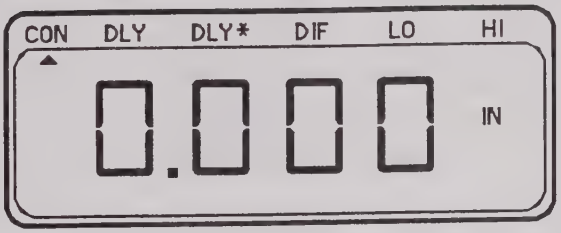


Figure 19

Press the **CAL** key. The display will appear as in figure 18. Use the **SCROLLING** keys to change the displayed value to the desired material velocity. Note that the digit select bar appears under the digit which is under active control of the scrolling keys. You may change the position of the digit select bar by using one of the **DIGIT** keys. This function can speed up the calibration procedure when it is necessary to make large changes in the displayed value.

Press the **CAL** key . Then press the **THK/MAT/μS** key twice. The display will appear as in figure 19. The CL304 is now calibrated and ready to measure test pieces of the selected material velocity.

Figure 20

2.9 Calibration to a Known Velocity—Metric Format

In the metric format, the CL304's material velocity range is 254,000 to 20,320,000 mm/s. This range of velocities is divided into two sub-ranges. Range 1 covers from 254,000 to 9,999,499 mm/s. These values are displayed as X.XXX mm/s where the implied multiplier is 10^6. This range covers nearly all commonly encountered materials. Reference Table 1 on page29.

To calibrate the CL304 to a known velocity, switch the instrument on and connect the desired probe. Use the **PROBE** key to put the CL304 in the proper operating mode. If a contact probe is used, perform the probe zero procedure described in section 2.5. Use the **THK/MAT/μS** key to change the displayed value to material velocity (mm/s). The display will show the velocity currently set in the instrument. Reference figure 20 as an example.

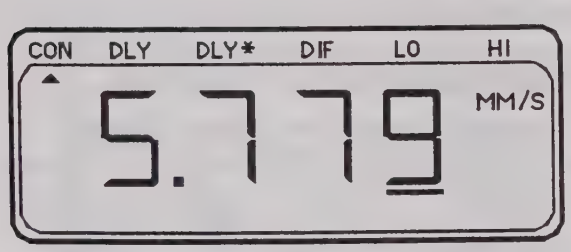


Figure 21

Press the **CAL** key. The display will appear as in figure 21. Use the **SCROLLING** keys to change the displayed value to the desired material velocity. Note that the digit select bar appears under the digit which is under active control of the scrolling keys. You may change the position of the digit select bar by using one of the **DIGIT** keys. This function can speed up the calibration procedure when it is necessary to make large changes to the displayed value.

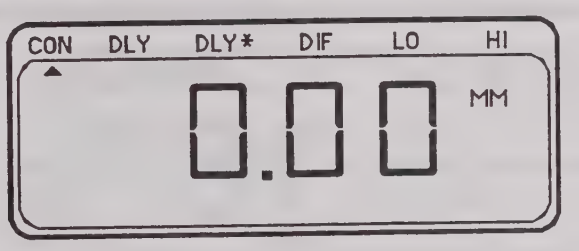


Figure 22

Press the **CAL** key. Then press the **THK/MAT/µS** key twice. The display will appear as in figure 22. The CL304 is now calibrated and ready to measure test pieces of the selected material velocity.

Figure 23

Figure 24

Range 2 covers from 9,999,500 to 20,320,000 mm/s. These values are displayed as XX.XX mm/s where the implied multiplier is 10^6. Range 2 may be necessary when measuring certain ceramic materials. Under normal conditions, a range 2 velocity can only be displayed and adjusted at a finest resolution of 10 m/s. Reference figure 23 as an example.

To display and adjust a range 2 velocity at a resolution of 1 m/s, press the **SHIFT** key followed by the **CAL** key while a range 2 velocity is being displayed. The most significant digit will *not* be displayed. The mm/s annunciator will blink to indicate this special condition. Reference figure 24. Use the **SCROLLING** and **DIGIT** keys to adjust the displayed value to the desired material velocity. To return to a resolution of 10 m/s, press the **SHIFT** key followed by the **CAL** key.

2.10 Table 1

Typical Sound Velocity (longitudinal wave) in various materials

	in/s (x 10^5)	mm/s (x 10^6)		in/s (x 10^5)	mm/s (x 10^6)
Aluminum	2.5	6.3	Nylon	1.0	2.6
Beryllium	5.1	12.9	Phenolic	0.56	1.4
Brass	1.7	4.4	Platinum	1.6	4.0
Cadmium	1.1	2.8	Plexiglas	1.1	2.7
Cast Iron	1.9	4.5	Polyethylene	0.7	1.9
Copper	1.8	4.7	Polystyrene	0.93	2.4
Diamond	6.9	17.5	Polyurethane	0.7	1.9
Glass (Crown)	2.2	5.7	Porcelain	2.2	5.6
Glass (Window)	2.7	6.8	Rubber (Butyl)	0.73	1.9
Gold	1.3	3.2	Rubber (Vulc.)	0.9	2.3
Inconel	2.2	5.7	Silver	1.4	3.6
Lead	0.85	2.2	Steel	2.3	5.9
Magnesium	2.3	5.8	Tin	1.3	3.3
Manganese	1.8	4.7	Titanium	2.4	5.9
Molybdenum	2.5	6.3	Tungsten	2.1	5.4
Neoprene	0.63	1.6	Zinc	1.6	4.2
Monel	2.1	5.4	Zircaloy 2	1.9	4.7
Nickel	2.2	5.6			

This information is supplied for the convenience of the user and Krautkramer Branson assumes no responsibility for inaccuracies. The actual velocity of the above materials is dependent upon the exact composition, temperature, and processing of each material.

2.11 Thickness Measurement

To perform thickness measurements with the CL304, first select the proper probe for the application and calibrate the gauge using one of the calibration procedures previously described. The importance of a proper calibration can not be overemphasized as the accuracy of the obtained thickness readings will only be as good as the calibration. Note: Periodic checks with samples of known thickness are strongly recommended as a check for proper instrument operation.

For best results, both the front and back surfaces of the test piece should be smooth and free from rust, corrosion, paint, etc. (If corroded material is to be measured, it is recommended that a gauge specifically designed for this application, such as the Krautkramer Branson DME, be used.) The front and back surfaces should also be parallel, although measurements on curved surfaces are entirely feasible and quite common.

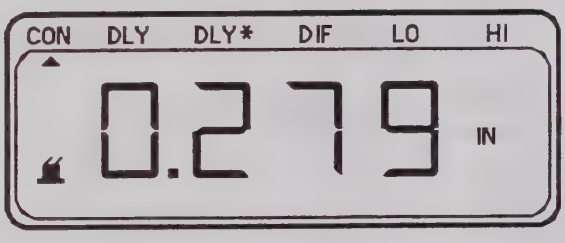


Figure 25

Apply a small amount of couplant to the test piece. Couple the probe to the test piece using a firm, steady pressure. The coupling indicator will light and the part thickness will be displayed. Reference figure 25. Some practice may be necessary to develop proper technique in using the probe. Unless care is exercised, it is possible to change the displayed thickness by varying the pressure with which the probe is held in contact with the test piece.

2.12 Manual Resolution Selection

The CL304 features auto-ranging (automatic selection of displayed resolution) as a means to provide the user with the best possible resolution for the part being measured with a four digit display. For example, using a contact type probe and measuring in inches, if the measured thickness of a particular part is less than 10 in, it will be displayed as 9.xxx in, with a resolution of .001in. However, if the part is thicker than 10 in, the CL304 will autorange and display the thickness as 10.xx in, with a resolution of .01 in.

In many measuring applications this automatic selection of displayed resolution is completely adequate. However, some applications may benefit from a selectable resolution. This section of the operating manual describes how to manually override the auto-ranging function.

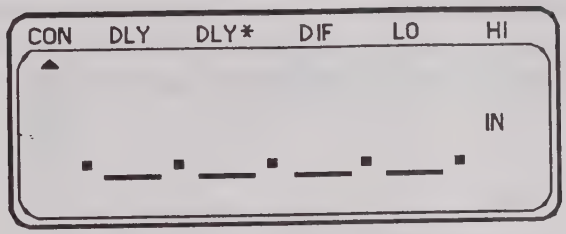


Figure 26

To manually override the auto-ranging function, the CL304 must be in the thickness measuring mode (IN or mm units displayed). To determine the current status of the auto/manual range function, press the **SHIFT** key and then the **RANGE** key. The state of the auto/manual range will be displayed for approximately 1 second. Reference figure 26. The display will appear as in figure 26 if auto-ranging is selected.

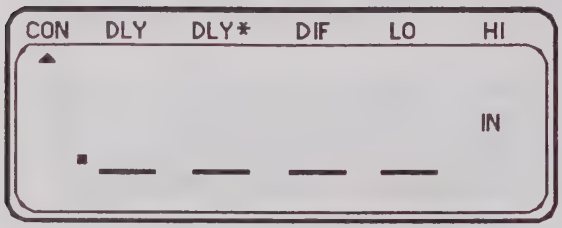


Figure 27

To fix the displayed resolution at four decimal places, press the **SHIFT** key and hold the **RANGE** key down until the display appears as in figure 27. Then release the **RANGE** key. The CL304 will revert to the measuring mode after approximately one second.

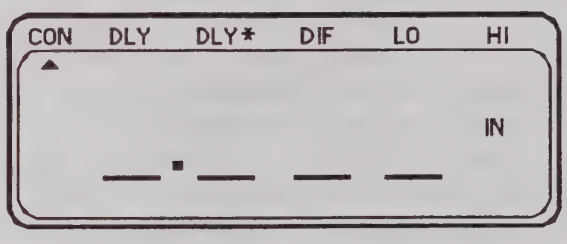


Figure 28

To fix the displayed resolution at three decimal places, press the **SHIFT** key and hold the **RANGE** key down until the display appears as in figure 28. Then release the **RANGE** key. The CL304 will revert to the measuring mode after approximately one second.

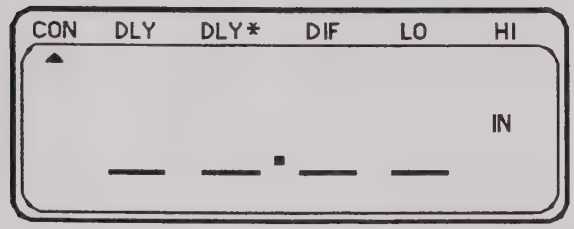


Figure 29

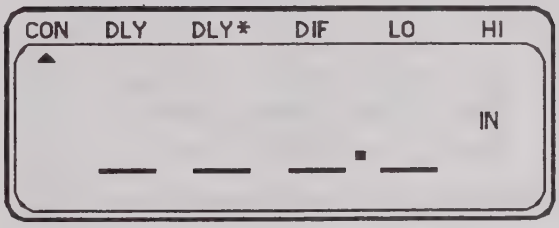


Figure 30

To fix the displayed resolution at two decimal places, press the **SHIFT** key and hold the **RANGE** key down until the display appears as in figure 29. Then release the **RANGE** key. The CL304 will revert to the measuring mode after approximately one second.

To fix the displayed resolution at one decimal place, press the **SHIFT** key and hold the **RANGE** key down until the display appears as in figure 30. Then release the **RANGE** key. The CL304 will revert to the measuring mode after approximately one second.

Continuing to hold the **RANGE** key down will return the CL304 to the auto-range display. Reference figure 26.

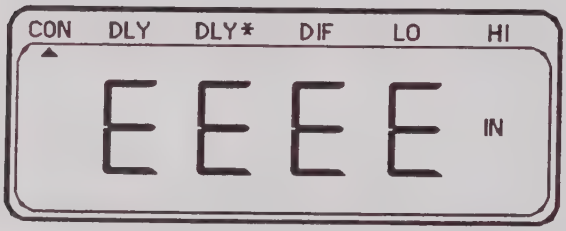


Figure 31

If, while using fixed resolution, a part is measured whose thickness exceeds the display's range, an over range error will be displayed. Figure 31. For example, with the resolution fixed at .0001inch, if a part thicker than .9999 inch is measured, the over range error will occur.

WARNING: Using the manual resolution selection feature of the CL304, it is possible to select a degree of resolution the instrument is not designed to provide, resulting in instability and inaccuracy in the least significant digit. Specifically, use of .0001 mm resolution in delay or contact mode and .0001 inch in the contact mode are **not** recommended.

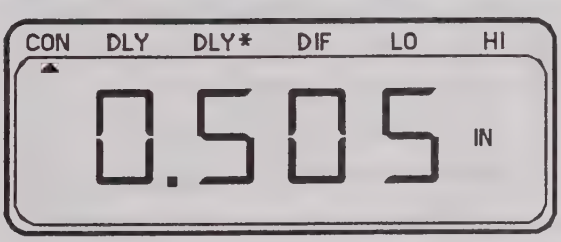


Figure 32

2.13 Velocity Measurement

In some applications, such as determining the percent nodularity of gray iron castings, the velocity of sound in a material may be of interest.

To measure this parameter, connect an appropriate probe to the instrument and use the **PROBE** key to put the CL304 into the proper operating mode, i.e. **CON**, **DLY**, or **DLY***. If a contact type probe is used, perform the probe zero procedure. (Reference section 2.5.) If necessary, use the **THK/MAT/μS** key to put the instrument into the thickness measuring mode (IN or mm displayed). Select the desired units of measurement, inches or millimeters, by pressing the **SHIFT** key followed by the **IN/mm** key.

Apply a small amount of couplant to a test piece whose thickness is accurately known. When a stable reading is obtained, remove the probe from the test piece. Reference figure 32.

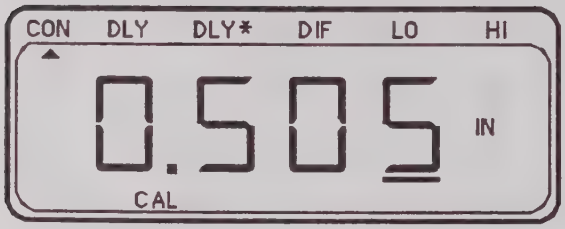


Figure 33

Press the **CAL** key. The display will appear as in figure 33.

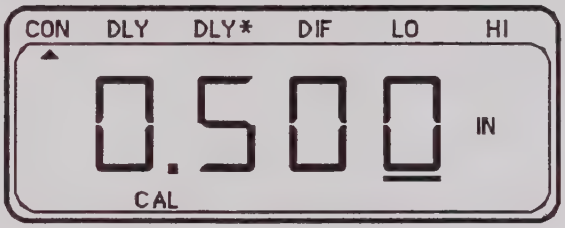


Figure 34

Use the **SCROLLING** and **DIGIT** keys to adjust the displayed thickness to the correct value. Reference figure 34.

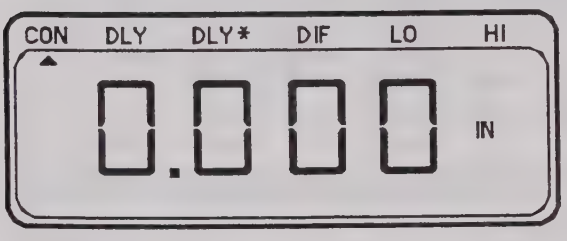


Figure 35

Press the **CAL** key. The display will appear as in figure 35.

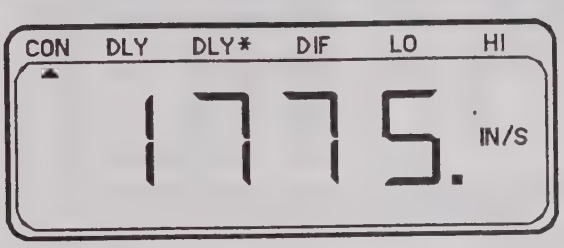


Figure 36

Press the **THK/MAT/µS** key. The velocity of sound in the test piece will be displayed (in/s or mm/s). Reference figure 36.

To measure the velocity of sound in another test piece, press the **THK/MAT/µS** key twice to return to the thickness measurement mode and follow the procedure just completed.

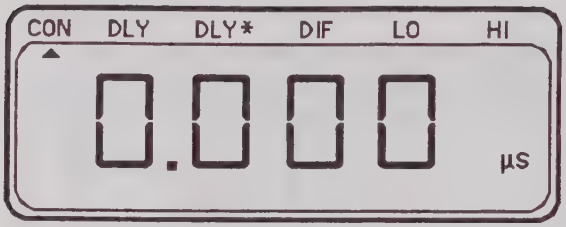


Figure 37

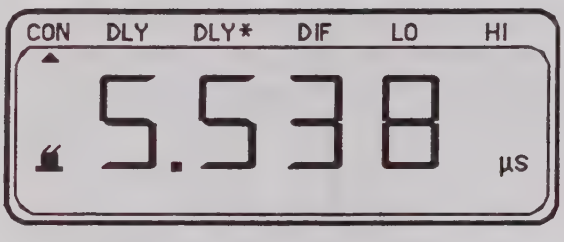


Figure 38

2.14 Time of Flight Measurement

In addition to thickness and velocity measurements, the CL304 may also be used to measure the *round trip* time of flight of the ultrasonic pulse in the test piece. The units are microseconds, µs. 1 µs = .000001 s.

To measure the round trip time of flight in a test piece, select an appropriate probe and calibrate the gauge using one of the calibration procedures previously described. Press the **THK/MAT/µS** key until the time of flight units, µs, are displayed. Reference figure 37. Apply a small amount of couplant to the test piece and couple the probe to it. The coupling indicator lights and the round trip time of flight will be displayed. Reference figure 38.

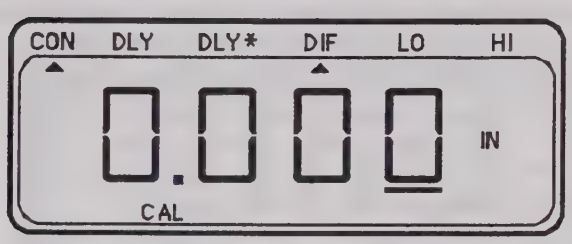


Figure 39

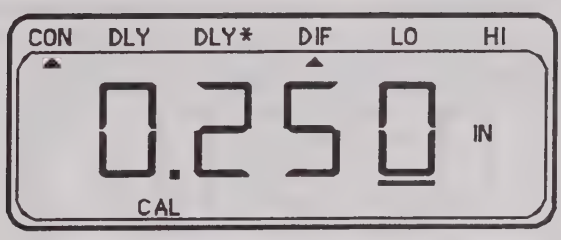


Figure 40

2.15 Differential Measurements

The CL304 is equipped with a differential operating mode which allows the gauge to display a thickness measurement as the *difference* between the actual measured thickness and a user programable nominal value, or differential offset.

To make differential measurements, select an appropriate probe and calibrate the gauge using one of the previously described calibration procedures. Press the **DIF/LO/HI** key once. A carat will light under **DIF** in the menu. Press the **CAL** key to display the differential offset value. Reference figure 39.

Use the **SCROLLING** and **DIGIT** keys to enter the desired nominal thickness value, or differential offset. Reference figure 40.

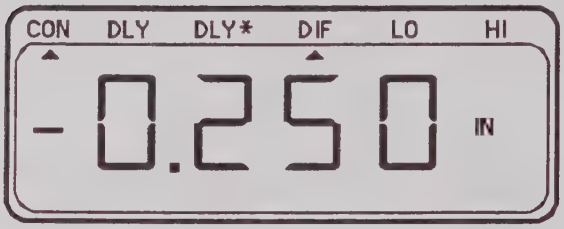


Figure 41

Figure 42

Press the **CAL** key. The display will show the differential offset value preceded by a minus sign. Reference figure 41. This is because prior to taking any thickness readings, in effect a thickness of 0.000 inch, the difference between a thickness of 0.000 and the differential offset value is -0.250.

Differential readings can now be taken. Apply a small amount of couplant to the test piece and couple the probe to it. If the thickness of the test piece is less than the differential offset value, the reading will be preceded by a minus sign. Reference figure 42 which represents the differential measurement for a thickness of 0.245 inch.

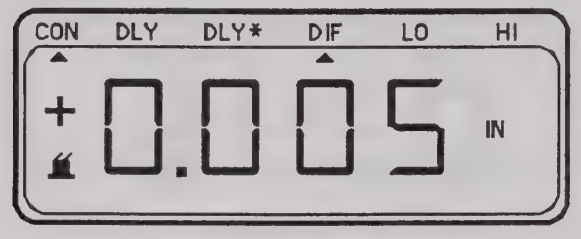


Figure 43

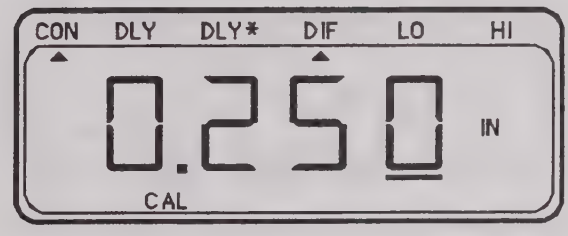


Figure 44

If the thickness of the test piece is greater than the differential offset value, the reading will be preceded by a plus sign. Reference figure 43 which represents the differential measurement for a thickness of 0.255 inch.

The nominal value of the differential offset can be checked at any time by pressing the **CAL** key. Reference figure 44.

Pressing the **CAL** key again returns the instrument to the differential measurement mode.

To return to the normal thickness measurement mode, press the **DIF/LO/HI** key three times or until no carats appear under **DIF**, **LO** or **HI** in the menu.

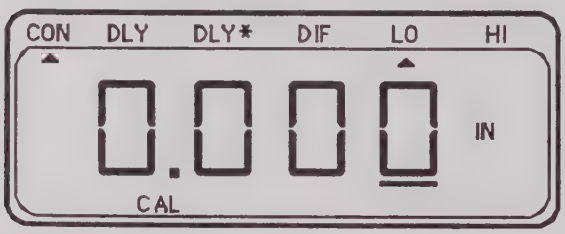


Figure 45

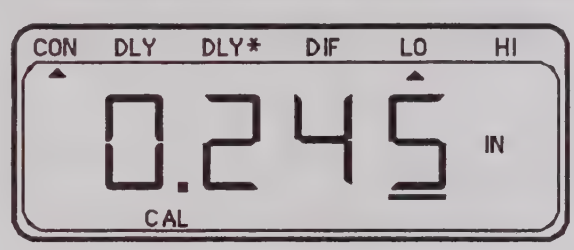


Figure 46

2.16 Hi/Lo Set Points with Alarm

The CL304 is equipped with high and low set points and an LED alarm to facilitate checking tolerances on a wide variety of parts. The high and low set points may be used individually or together to define a range of acceptable thicknesses.

To set the low set point, press the **DIF/LO/HI** key until a carat lights under **LO** in the menu. Press the **CAL** key. The display will appear as in figure 45.

Use the **SCROLLING** and **DIGIT** keys to enter the desired low set point value. Reference figure 46.

Press the **CAL** key again to lock the set point value.

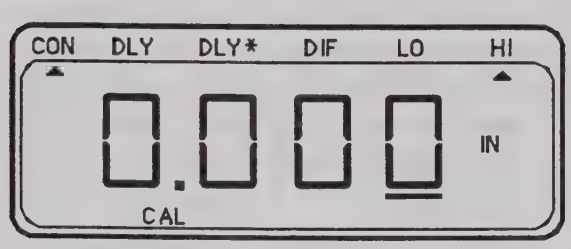


Figure 47

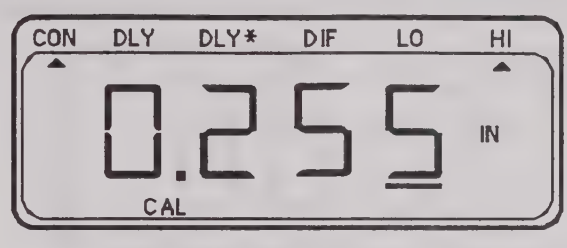


Figure 48

To set the high set point, press the **DIF/LO/HI** key until a carat lights under **HI** in the menu. Press the **CAL** key. The display will appear as in figure 47.

Use the **SCROLLING** and **DIGIT** keys to enter the desired high set point value. Reference figure 48.

Press the **CAL** key again to lock the set point value.

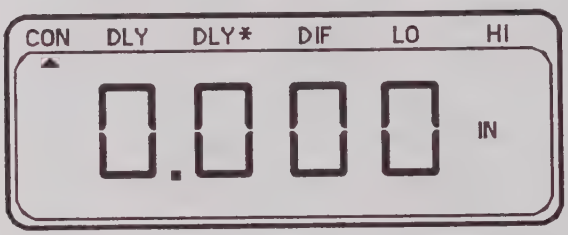


Figure 49

Figure 50

To take thickness measurements using the high and low set points, put the instrument into the normal thickness measurement mode by pressing the **DIF/LO/HI** key until no carats light under **DIF**, **LO**, or **HI** in the menu. Reference figure 49.

The alarm function must be enabled by pressing the **SHIFT** key followed by the **ALARM** key. The LED alarm will illuminate to signify that the alarm function is enabled.

Apply a small amount of couplant to the test piece and couple the probe to it. If the displayed thickness of the test piece is greater than the low limit and less than the high limit, the LED alarm to the left of the display will glow green, indicating an acceptable thickness. Reference figure 50.

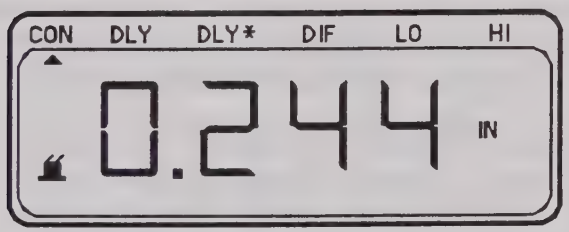


Figure 51

If the displayed thickness is less than the low limit or greater than the high limit, the LED alarm will glow red, indicating an out of tolerance condition. Reference figure 51.

In addition to the LED alarm, the system timing output connector on the rear panel of the CL304 carries TTL level alarm signals on pins 13 and 14.

The alarm may be turned off by pressing the **SHIFT** key followed by the **ALARM** key.

Once disabled, the alarm function may be re-enabled by pressing the **SHIFT** key followed by the **ALARM** key.

2.17 DLY* (Plastics) Mode

Measuring the thickness of plastics parts can often present problems. The low acoustic impedance of many plastics can make measurement with delay type probes inaccurate or impossible and standard contact probes often do not have sufficient minimum thickness measurement capability.

To facilitate the measurement of plastic parts as thin as .010 inch (.25 mm), the CL304 is equipped with a plastics operating mode, **DLY***, designed to be used with the special Krautkramer Branson plastics probe. Note: Use the special plastics probe *only* in the **DLY*** operating mode.

To use the **DLY*** mode, press the **PROBE** key until the carat lights under **DLY*** in the menu. Reference figure 52. Note that resolution in the inch mode is .0001 inch. Metric resolution is .01 mm.

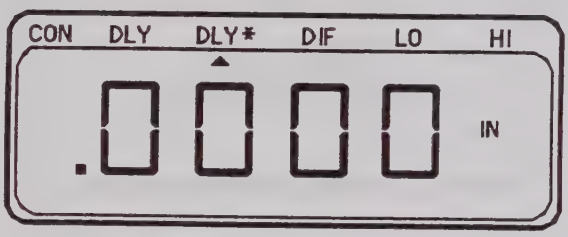


Figure 52

Since the plastics probe is a contact design, it is necessary to perform the probe zero procedure described in Section 2.5. After performing the probe zero procedure, calibrate the instrument to a known thickness calibration standard of the same material to be measured per Section 2.6, or to a known material velocity value per Section 2.8 or 2.9.

3.1 Special Menu Function

The standard CL304 is an extremely versatile instrument, capable of satisfying a very wide variety of thickness measuring applications. However, some particularly difficult or unusual measurement applications may require adjustments to one or more instrument operating parameters. The CL304 special menu function allows adjustment of the following instrument parameters from the front panel keyboard: probe type, delay I, delay II, delay III, stage 1 gain, stage 2 gain, AGC limit, pulser repitition rate, number of shots, receiver phase select, interface phase select, and TGC slope. In addition to enabling these adjustments, the special menu function allows up to seven of these customized instrument set-ups to be stored for future use in non-volatile (nv) memory banks. Note that the **!** indicator will light in the display when one of the custom memory banks is active.

Warning: Making adjustments to any of these instrument parameters will affect the performance of the CL304 for normal thickness measurement applications. These parameters should not be changed unless a measurement application specifically requires it. These adjustments should not be attempted without viewing their signals on an oscilloscope to verify the parameter settings. **Changes to these instrument parameters should not be attempted by personnel unfamiliar with the nature of these parameters, their signals as viewed on an oscilloscope, and the effects any changes may have on normal instrument performance.** The default value for any parameter may be selected by pressing the **SHIFT** key followed by the **CAL** key when the **CAL** indicator is not lit.

The factory calibrated settings for the CL304 may always be restored by setting operation to memory bank 0.

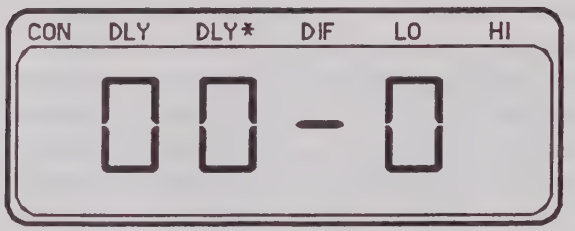


Figure 53

The special menu is accessed by pressing the **SHIFT** key followed by the **MENU** key. Note: The special menu can *not* be accessed while the **CAL** indicator is lit.

The instrument will display two sets of numbers in the format XX-Y. Reference figure 53. XX is the menu item number from 00-12. The special menu item numbers and their corresponding parameters are presented in Table 2. Y is the parameter option number used to select or set new values for the parameter shown in the menu.

Table 2
Special Menu Item Numbers and Corresponding Parameters

Menu Item Number	Parameter
00	Memory bank number
01	Probe type
02	Delay I length
03	Delay III length
04	Delay II length
05	Stage 1 gain
06	Stage 2 gain
07	AGC limit
08	Pulser rep rate
09	Number of shots
10	Receiver phase select
11	Interface phase select
12	TGC level

3.2 Special Menu Controls

The following controls are used when operating the special menu function:

The **CAL** key toggles the CAL indicator on and off.

The **SCROLL UP** key increments the parameter option number or the actual parameter value. Active only when the **CAL** indicator is lit.

The **SCROLL DOWN** key decrements the parameter option number or the actual parameter value. Active only when the **CAL** indicator is lit.

The **DIGIT LEFT** key steps the menu item number backward to the previous menu item. Active only when the **CAL** indicator is off.

The **DIGIT RIGHT** key steps the menu item number forward to the next menu item. Active only when the **CAL** indicator is off.

The **SHIFT** key is only active when the **CAL** indicator is off. When pressed the **SHIFT** indicator will light in the display. **SHIFT CAL** will select the default value for any special menu parameter. **SHIFT MENU** will enter/exit the special menu.

3.3 Memory Bank Selection

The CL304 has eight non-volatile (nv) memory banks. Seven are available for storing customized instrument set-ups. In the XX-Y special menu display format, memory bank selection is menu item number 00 and the parameter option number, Y, can be 0-7. Memory bank selection is the first menu item displayed when the special menu function is accessed by pressing the **SHIFT** key followed by the **MENU** key. Reference figure 53. (This is true when the special menu is accessed for the *first* time after turning the instrument on. Subsequent accessing of the special menu will result in entering the special menu at the last menu item that was selected before exiting the special menu.)

Memory bank 0 is where the default values for all instrument parameters are stored. No other menu items will be available for change by the user while memory bank 0 is active. The factory calibrated settings for the CL304 may always be restored by setting the menu item number to 00 and the parameter option to memory bank 0.

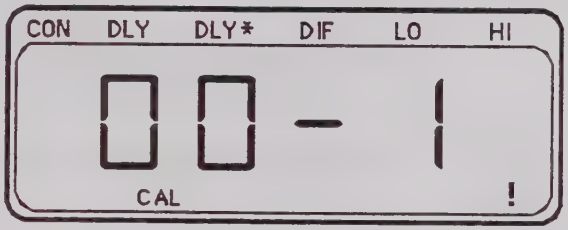


Figure 54

Memory banks 1-7 are user definable. All other menu items are available for change. To select one of the user definable memory banks, first press the **CAL** key. Use the **SCROLLING** keys to change the parameter option number. Note that the **!** indicator is lit when memory banks 1-7 are selected. Reference figure 54.

3.4 Probe Type Selection

When setting up one of the memory banks (banks 1-7) for a special test application, the probe type **must** be set before any other parameter. To set the probe type, select the desired memory bank (1-7) as described in section 3.3. Turn off the **CAL** indicator by pressing the **CAL** key. Press the **DIGIT** key to advance the menu item number to item number 01. 01-Y will be displayed, where Y identifies which probe configuration is active. Reference figure 55. There are five probe configuration options available, numbered 0 through 4.

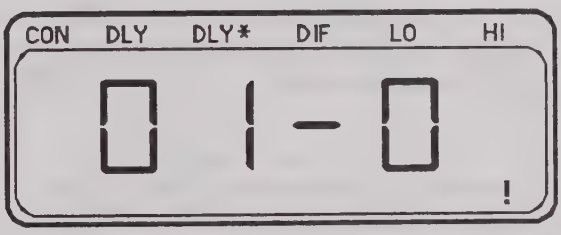


Figure 55

Option 0	Selects a contact type probe. This is the default option.
Option 1	Selects a delay type probe. The CL304 will automatically determine which delay method to use, either multi-echo or interface to first.
Option 2	Selects a delay type probe. The measurement method will be fixed as interface to first.
Option 3	Selects a delay type probe. The measurement method will be fixed as multi-echo.
Option 4	Selects a plastics type (DLY*) probe.

Press the **CAL** key to light the **CAL** indicator. Use the **SCROLLING** keys to choose the desired probe configuration.

NOTE: For any configurable memory bank, special menu items 02 through 12 will assume their default settings whenever the probe configuration is changed. This is done for the following reasons:
1) Special menu parameters that may have been configured for one type of probe may cause unreliable results when used with another type of probe, 2) the CL304 can only retain settings for one type of probe in each memory bank.

The **PROBE** key will be disabled while memory banks 1-7 are active and the CL304 is in a measurement mode. The probe type must be selected through the special menu for banks 1-7.

3.5 Delay I Length Selection

Delay I is a programmable time delay used for main bang ringing blockout in delay mode measurements. Delay I can be adjusted to allow the use of lower frequency delay type and immersion probes when measuring attenuative materials such as cast iron or teflon. **Setting Delay I length should not be attempted without viewing the appropriate signals on an oscilloscope.** For proper connection of the system timing signals to an oscilloscope refer to Appendix A.

To set Delay I length, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Press the **DIGIT** key to advance the menu item number to item number 02. 02-Y will be displayed (figure 56), where Y identifies the condition of Delay I. If Y=0, Delay I is set to the default value. If Y=1, Delay I is not set to the default value. To adjust Delay I, press the **CAL** key.

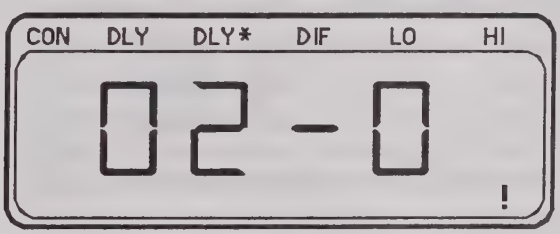


Figure 56

The length of Delay I will be displayed while the **CAL** indicator is lit. Reference figure 57. The value will be displayed in the format XXX.X µs and have a range of .2 µs to 999.9 µs. The **SCROLLING** keys can be used to adjust the length of Delay I to the desired value. The scrolling increment is .2µs per step. For proper operation,

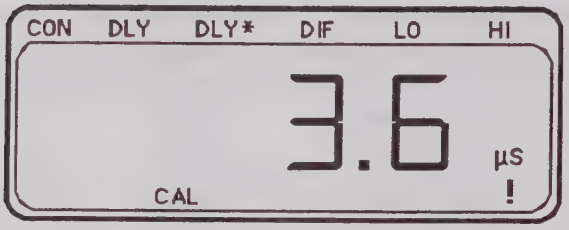


Figure 57

Delay I should extend just beyond any main bang ringing in the RF waveform when viewed on the oscilloscope. The error message EEEE will be displayed if the length of Delay I exceeds 999.9 µs.

To select the default setting (for the selected probe type), press the **SHIFT** key followed by the **CAL** key. The default value will be different for each probe type.

To exit the special menu and return to a measurement mode, press the **SHIFT** key followed by the **MENU** key.

3.6 Delay III Length

Delay III is a programmable time delay that establishes a "valid couple" range. In contact mode, Delay III is set to 340.4 µs, the equivalent of 39.37 inches of steel. If no echoes are detected within this time window, the instrument considers the probe to be uncoupled. In the delay mode, the CL304 automatically measures the length of the acoustic delay line and sets Delay III equal to approximately twice this value. Delay III will start at pulser fire and end just before the second delay tip multiple. If an appropriate number of echoes is not detected within this time window, the CL304 will consider the probe to be uncoupled.

Delay III will normally not require any adjustment. However, in some applications where it is necessary to view the RF waveforms on an oscilloscope, it may be desireable to increase the pulser repitition rate (see section 3.11) in order to provide a brighter display on the oscilloscpe. If the rep rate is set to 3 kHz. or greater, Delay III must be shortened so that it is less than the interval between two successive pulser firings. If this is not done, the CL304 will interpret the firing of the pulser as an echo and measurements will be impossible.

Adjusting Delay III should not be attempted without viewing the appropriate signals on an oscilloscope.

To adjust Delay III, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Press the **DIGIT** key to advance the menu item number to item number 03. 03-Y will be displayed (figure 58), where Y identifies the condition of Delay III. If Y=0, Delay III is set to its default value. If Y=1, Delay III is not set to its default value. To adjust Delay III press the **CAL** key. The length of Delay III will be displayed while the **CAL** indicator is lit. Refer-

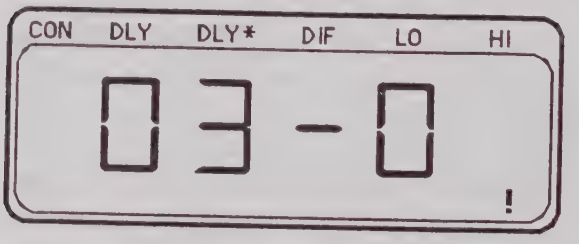


Figure 58

ence figure 59. The value will be displayed in the format XXX.X µs and have a range of .2 µs to 999.9 µs. The scrolling increment is .2µs per step. The **SCROLLING** keys can be used to adjust the length of Delay III to the desired value. The error message EEEE will be displayed if the length of Delay III exceeds 999.9 µs.

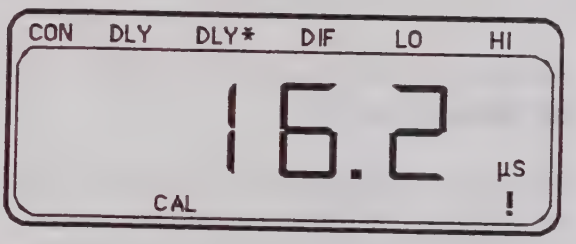


Figure 59

To select the default value of Delay III (for the selected probe type), press the **SHIFT** key followed by the **CAL** key. The default value may be different for each probe type.

To exit the special menu and return to a measurement mode, press the **SHIFT** key followed by the **MENU** key.

3.7 Delay II Length

Delay II is a programmable time delay that serves two functions. In contact mode, Delay II is used for main bang ringing blockout. In delay mode, Delay II is used for ringing blockout at the delay line/test piece interface. Delay II can be adjusted to allow the use of lower frequency probes, contact or delay, in order to measure more attenuative materials such as cast iron or teflon. It is important to note that adjusting Delay II will affect the minimum measuring range of the CL304. If Delay II is increased, the minimum measuring range will also be increased. **Adjusting Delay II should not be attempted without viewing the appropriate signals on an oscilloscope.**

For proper connection of the system timing signals to an oscilloscope refer to Appendix A.

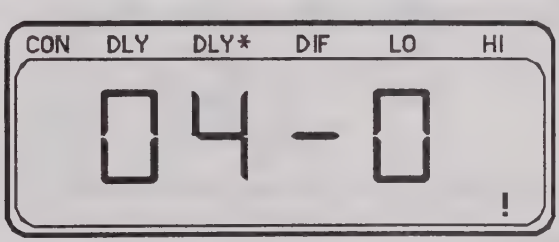


Figure 60

To adjust Delay II length, first select a memory bank (section 3.3) and a probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Press the **DIGIT** key to advance the menu item number to item number 04. 04-Y will be displayed (figure 60) where Y indicates the condition of Delay II. If Y=0, Delay II is set to its default value. If Y=1, Delay II is not set to its default value.

Figure 61

To adjust the length of Delay II press the **CAL** key. The value of Delay II will be displayed while the **CAL** indicator is lit. Reference figure 61. This is only a reference number with a range of 0 to 255. The actual length of Delay II must be measured externally with an oscilloscope. The **SCROLLING** keys can be used to adjust the length of Delay II.

To select the default setting (for the probe type selected) press the **SHIFT** key followed by the **CAL** key.

To exit the spercial menu and return to a measurement mode, press the **SHIFT** key followed by the **MENU** key.

3.8 Stage 1 Gain Level

The CL304 receiver has two stages of amplification. The overall level of gain the amplifier is allowed to reach is controlled by the AGC, or Automatic Gain Control, circuit (see section 3.10). The *balance* between the two stages of amplification can be affected by varying the Stage 1 and/or the Stage 2 gain levels. It is important to note that varying the Stage 1 or Stage 2 gain levels will also affect the recovery characteristics, i.e. how fast the receiver is able to recover from pulser ringing and be ready to recognize backwall echoes. This in turn affects the minimum measuring range of the instrument. Increases in Stage 1 gain level can result in an increase in the minimum thickness the CL304 is able to measure. **Adjusting Stage 1 gain should not be attempted without viewing the appropriate signals on an oscilloscope.** The level of Stage 1 gain can be viewed by observing the amplitude of the RF waveform.

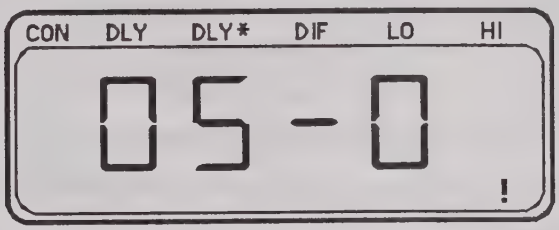


Figure 62

To adjust Stage 1 gain, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** key to advance the menu item number to item number 05. 05-Y will be displayed (figure 62) where Y indicates the condition of Stage 1 gain. If Y=0, Stage 1 gain is set to its default value. If Y=1, Stage 1 gain is not set to its default value.

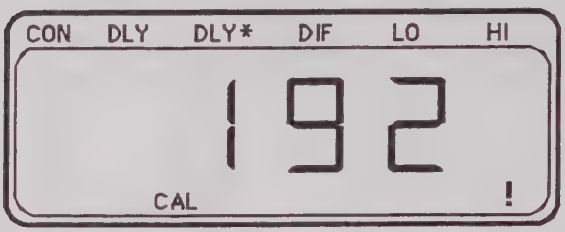


Figure 63

To adjust the level of Stage 1 gain, press the **CAL** key. The value of Stage 1 gain will be displayed while the **CAL** indicator is lit. Reference figure 63. This is a reference value with a range of 0 to 255. As noted previously, the effect of varying Stage 1 gain is seen by observing the change in amplitude of the RF waveform. The **SCROLLING** keys can be used to adjust the level of Stage 1 gain.

Note: Increasing the displayed value of Stage 1 gain results in a *decrease* in the gain level for this stage. Decreasing the displayed value for Stage 1 gain results in an *increase* in the gain level for this stage.

To select the default setting (for the probe type selected) press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measuring mode, press the **SHIFT** ket followed by the **MENU** key.

3.9 Stage 2 Gain Level

The CL304 receiver has two stages of amplification. The overall level of gain the amplifier is allowed to reach is controlled by the AGC, or Automatic Gain Control, circuit (see section 3.10). The *balance* between the two stages of amplification can be affected by varying the Stage 1 and/or the Stage 2 gain levels. It is important to note that varying the Stage 1 or Stage 2 gain levels will also affect the recovery characteristics, i.e. how fast the receiver is able to "recover" from the main bang ringing and be ready to recognize backwall echoes. This in turn affects the minimum measuring range of the instrument. Increases in Stage 2 gain level can result in an increase in the minimum thickness the CL304 is able to measure. **Adjusting Stage 2 gain should not be attempted without viewing the appropriate signals on an oscilloscope.** The level of Stage 2 gain can be viewed by observing the amplitude of the RF waveform.

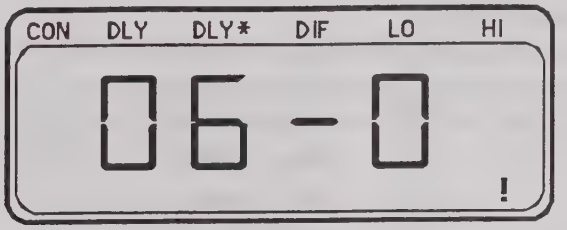


Figure 64

To adjust Stage 2 gain, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** key to advance the menu item number to item number 06. 06-Y will be displayed (figure 64) where Y indicates the condition of Stage 2 gain. If Y=0, Stage 1 gain is set to its default value. If Y=1, Stage 2 gain is not set to its default value.

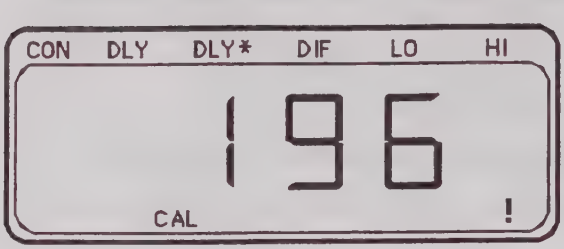


Figure 65

To adjust the level of Stage 2 gain, press the **CAL** key. The value of Stage 1 gain will be displayed while the **CAL** indicator is lit. Reference figure 65. This is a reference value with a range of 0 to 255. As noted previously, the effect of varying Stage 2 gain is seen by observing the change in amplitude of the RF waveform. The **SCROLLING** keys can be used to adjust the level of Stage 2 gain.

Note: Increasing the displayed value for Stage 2 gain will result in a *decrease* in the gain level for this stage. Decreasing the displayed value for Stage 2 gain will result in an *increase* in the gain level for this stage.

To select the default setting (for the probe type selected) press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measuring mode, press the **SHIFT** ket followed by the **MENU** key.

3.10 AGC Level

The CL304 has a maximum receiver gain of 70 dB. The gain level the amplifier is allowed to reach is controlled by the Automatic Gain Control (AGC) circuit. In some applications, such as measuring very grainy or acoustically "noisy" materials with a contact probe, it may be beneficial to reduce the AGC level to reduce the possibility of having the instrument read noise instead of legtimate backwall echoes. Increasing the AGC level may be useful when measuring highly attenuative materials such as teflon. It is important to note that adjustments to the AGC level may affect the minimum measuring range of the instrument. **Adjusting the AGC level should not be attempted without viewing the appropriate signals on an oscilloscope.** The AGC level can be viewed by observing the amplitude of the RF waveform.

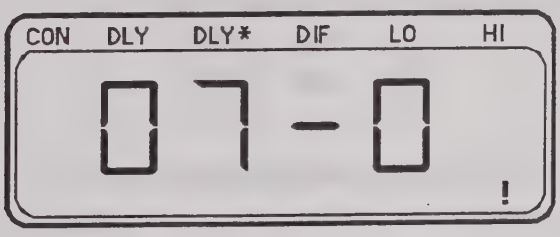


Figure 66

To adjust the AGC level first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** key to advance the menu item number to item number 07. 07-Y will be displayed (figure 66) where Y indicates the condition of the AGC level. If Y=0, the AGC level is set to its default value. If Y=1, the AGC level is not set to its default value.

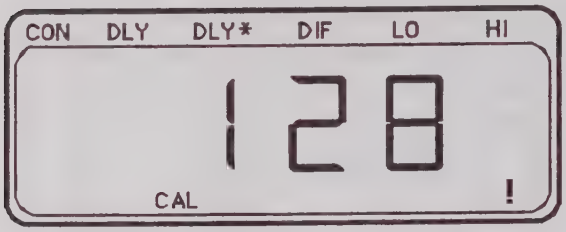


Figure 67

To adjust the AGC level, Press the **CAL** key. The value of the AGC level will be displayed while the **CAL** indicator is lit. Reference figure 67. This is a reference value with a range of 0 to 255. As noted previously, the effect of varying the AGC level is seen by observing the amplitude of the RF waveform. The **SCROLLING** keys can be used to adjust the AGC level.

To select the default value (for the probe type selected) press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measuring mode, press the **SHIFT** key followed by the **MENU** key.

3.11 Pulser Repitition Rate

The CL304 pulser repitition rate is normally set automatically for the type of probe that is selected. However, in some cases it may be useful to change the pulser repitition rate. In those applications which require echo waveforms to be viewed on an oscilloscope, the display can be made brighter by increasing the repitition rate. The repitition rate may need to be decreased when the measuring application requires a squirter type probe using a long water path so that the pulser firing does not occur in the measurement time window. **Adjustments to the pulser repitition rate should not be attempted without viewing the appropriate signals on an oscilloscope.**

In contact mode measurements, if the pulser repitition rate is increased, Delay III may need to be shortened to ensure that Delay III ends before the next pulser firing.

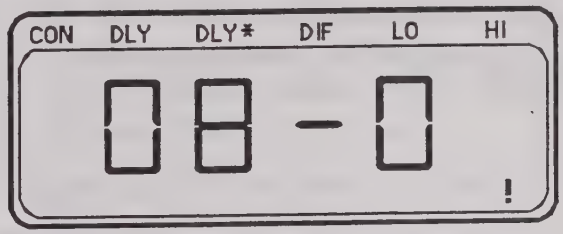


Figure 68

To adjust the pulser repitition rate first select a memory bank (section 3.3) and a probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key.

Use the **DIGIT** key to advance the menu item number to item number 08. 08-Y will be displayed (figure 68) where Y indicates the condition of the pulser repitition rate. If Y=0, the pulser repitition rate is set to its default value. If Y=1, the pulser repitition rate is not set to its default value. To adjust

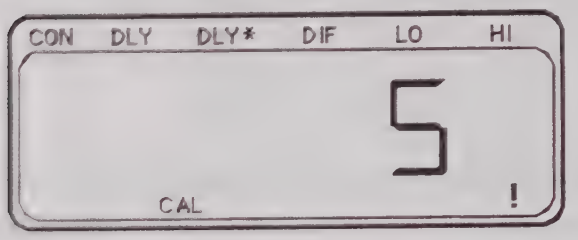


Figure 69

the pulser repitition rate press the **CAL** key. A reference value from 2 to 255 will be displayed. Reference figure 69. The pulser repitition rate is equal to 50kHz divided by the displayed value. For example, if the displayed value is 5, the pulser repitition rate is equal to 50 kHz ÷5, or 10 kHz.

The range of displayed values for pulser repitition rates is from 2 to 255. This corresponds to a frequency range of 25 kHz (value of 2) to 196 Hz (value of 255).

The **SCROLLING** keys can be used to adjust the value of the pulser repitition rate.

To select the default value (for the probe type selected) press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measuring mode, press the **SHIFT** key followed by the **MENU** key.

3.12 Number of Shots to Average

The CL304 achieves its high resolution by averaging a number of thickness readings, or "shots". In normal operation the number of shots necessary is determined automatically by the CL304 based on the material velocity and the required resolution. This is the default setting for this parameter. Note: the CL304 normally oversamples beyond the required resolution to ensure stability of the least significant digit.

In some instances it may be useful to change the number of shots to average, e.g. in the contact mode, if the resolution has been fixed at .0001 inch rather than the standard .001 inch, one hundred times as many shots are necessary to stabilize the displayed thickness value.

To adjust the number of shots to average, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** key to advance the menu item number to item number 09. 09-Y will be displayed (figure 70) where Y indicates the condition of the number of shots to average parameter. If Y=0, the number of shots is determined automatically by the CL304 (the default condition). If Y=1, the automatic shots mode is disabled and that the number of shots has been fixed. To adjust the number of shots press the **CAL** key.The number of shots being used will be displayed. Reference figure 71.

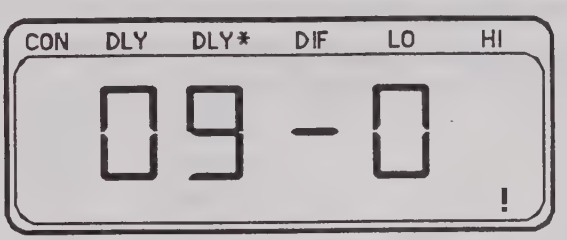


Figure 70

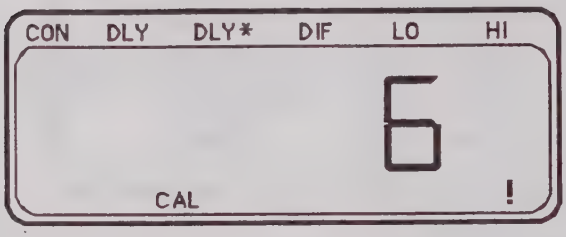


Figure 71

The **SCROLLING** keys can be used to adjust the number of shots to average.

In normal operation the CL304 has a display update rate of 5 Hz which is sufficient for virtually instantaneous aquisition and display of thickness readings. It is important to note that if the number of shots multiplied by the pulser repitition time (time = 1/rep rate) exceeds .2 seconds, then the thickness reading will take longer to aquire and display.

The number of shots has the following ranges:

Contact mode: 1 to 395
Delay mode: 1 to 9,999 *

* The display will show **EEEE** if a number of shots greater than 9,999 is selected.

To select the default (automatic) setting (for the probe type selected), press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measurement mode, press the **SHIFT** key followed by the **MENU** key.

3.13 Receiver Phase Invert

In many common thickness measurement applications for delay type probes, the backwall echo is from a high impedance (the part) to low impedance (air or fluid behind the part) interface. The CL304 automatically inverts the phase of this backwall echo to determine the correct part thickness. However, in measurement applications where the backwall echo is from a low impedance (e.g. plastic) material bonded to a high impedance (e.g. metal) material, inverting the phase of the backwall echo is not desireable.

To disable the automatic receiver phase inversion, first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** keys to advance the menu item number to item number 10. 10-Y will be displayed (figure 72)

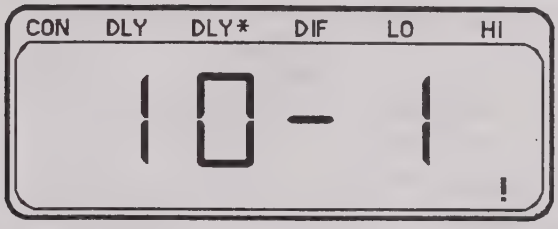


Figure 72

where Y indicates the state of the receiver inversion. If Y=0, the receiver phase is being inverted. If Y=1, the receiver phase is not being inverted (the default condition). To change the state of the receiver inversion press the **CAL** key. The **SCROLLING** keys can be used to change the state of the receiver inversion.

To select the default mode (for the probe type selected) press the **SHIFT** key followed by the **CAL** key. To exit the special menu and return to a measurement mode press the **SHIFT** key followed by the **MENU** key.

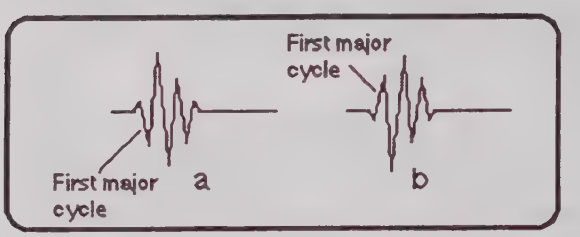


Figure 73

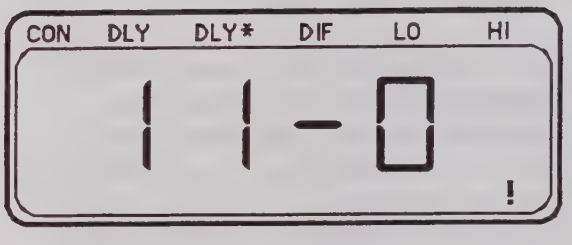


Figure 74

3.14 Interface Phase Selection

The Krautkramer Branson probes designed for use on the CL304 have a first major cycle that is negative. Reference figure 73a. The CL304 is programmed for echoes generated by these probes. Some probes, however, have positive first major cycles (figure 73b) (When using probes that are not specified for use on the CL304, the polarity of the first major cycle should be verified by observing the RF waveform on an oscilloscope.) If a probe with a positive first major cycle must be used, it may be desireable to invert the interface phase. The need to do this depends on the material being measured as well as the probe. When using probes other than those specifically recommended for the CL304, some experimentation may be necessary to determine whether interface phase inversion is necessary. To change the interface phase selection first select a memory bank (section 3.3) and probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** keys to advance the menu item number to item 11. 11-Y will be displayed (figure 74) where Y indicates the interface phase selection. If Y=0, the interface is not

being inverted (the default condition for contact style probes). If Y=1, the interface is being inverted (the default condition for delay type probes). To change the interface phase selection press the **CAL** key. The **SCROLLING** keys can be used to change the interface phase. It is important to note that if the interface phase is being inverted, then it will most likely be necessary to invert the receiver phase as well (see section 3.13).

To select the default condition for the interface phase inversion press the **SHIFT** key followed by the **CAL** key.

To exit the special menu and return to a measurement mode press the **SHIFT** key followed by the **MENU** key.

3.15 TCG Slope

The time compensated gain (TCG) feature of the CL304 has two functions. In contact mode it changes the rate at which the receiver gain is increased with time, facilitating the measurement of thick and/or attenuative test pieces. In the multiecho delay mode it is used to bring the second multiple of the backwall echo up to the level of detection.

The CL304 has four different TCG slopes available, numbered 0-3, with 0 being the slowest and 3 the fastest slope. The default setting will be different for different probe types. When measuring very thick or very attenuative materials such as teflon or cast iron, it may be helpful to increase the TCG slope.

To change the TCG slope, first select a memory bank (section 3.3) and a probe type (section 3.4). Turn off the **CAL** indicator if necessary by pressing the **CAL** key. Use the **DIGIT** keys to advance the menu item number to item number 12. 12-Y will be displayed (figure 75) where Y indicates which TCG slope is active.

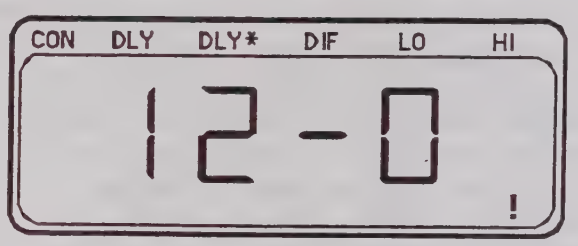


Figure 75

To change the TCG slope press the **CAL** key. Use the **SCROLLING** keys to change the TCG slope value. To select the default TCG slope (for the probe type selected) press the **SHIFT** key followed by the **CAL** key. To exit the special menu and return to a measurement mode, press the **SHIFT** key followed by the **MENU** key.

4.1 CL304 Specifications

Operati ng Principle:	Ultrasonic, pulse echo measurement method
Material Sound Velocity Range:	.1 to 8.0 x 10^5 inches/s 254 to 20,320 meter/s
Velocity Resolution:	100 inches/s, 1 meter/s internally stored to 1 inch/s, .0254 m/s
Displayed Resolution:	Autorange or selectable: .0001, .001, .01 inch or .001, .01,.1 mm
Obtainable Accuracy:	Time accuracy ± .005% ± 1 count of the least significant digit. Measurement accuracy dependent on calibration, uniformity of velocity, and operator technique.
Reading Stability as a Function of Temperature:	± 2 counts of least significant digit
Linearity: Delay Mode	± 2 counts of least significant digit when measuring ≥ .040 inch (1.0mm) ± 3 counts of least significant digit when measuring < .040 inch (1.0mm)
Contact Mode	± 2 counts of least significant digit

Linearity: DLY* (plastics) Mode	± .001 inch (.025 mm)
Pulser:	
Rep Rate:	Adjustable; 196 Hz to 25 KHz
Voltage:	-60V peak into open circuit
Fall Time:	5 ns
Receiver:	
Bandwidth:	1.5 to 30 MHz @ -3 dB
Total Gain:	60 dB
Operating Modes:	
Measurement Technique:	Contact; Excitation to first backwall echo, fixed gain.
	Delay; Multiple echo for thicknesses 0 to approximately 1/2 delay line length. Interface to first backwall echo for thicknesses greater than 1/2 delay line length. Interface phase inversion.
	DLY*;Special plastics contact mode.

Differential Mode:	Offset programmable: 0-15 in, 0-300 mm. Differential display can be enabled or disabled from front panel (DIF, LO, HI key
HI/LO Set with Alarm:	High and low set point limits programmable: 0-15 in, 0-300 mm. Alarm enabled or disabled from front panel (ALARM key). Alarm LED off when alarm disabled. Alarm LED green when alarm enabled but not violated. Alarm LED red when alarm enabled and violated.
Calibration:	
Contact:	Semi automatic zero adjustment on known thickness zero block. One point off block, enter velocity or thickness.
Delay/Immersion:	No zero adjustment. One point, off block. Enter velocity or thickness.
Time of Flight:	Displayed in microseconds (10^{-6} s) Resolution of 1 nanosecond (1 nanosecond $=10^{-9}$ s)

4.0 Specifications

Display Type:	LCD, 4 digit, .5 inch high digits
Update Rate:	5 Hz. (under most conditions)
Backlight:	Automatic, electroluminescent
Last Reading Hold:	Last reading held indefinitely
Displayed Information:	Thickness Material Velocity Time of Flight Inches **(IN)** millimeters **(mm)** microseconds **(µs)** Special Operating Mode **(!)** Low Battery **(LO BAT)** Coupling Calibration mode **(CAL)** **SHIFT** **REMOTE**
Power Requirements:	4 each, "D" size rechargable NiCad or Alkaline, 2.5 watts, 4.0 to 7.0 VDC. 120V/60 Hz AC.
Battery Life/Operating Time:	8 hours on Nicad batteries 10 hours on alkaline cells

Low Battery Indicator:	Indicator lit when low battery point is reached, i.e. approximately 20 minutes of operating time remaining. When batteries reach exhaustion, LO BAT symbol is lit, remainder of display is blanked, and instrument goes into idle mode.
Battery Charger/Eliminator:	Batteries will charge while instrument is operating. Recharge time of 14 hours. Battery charger can be left connected indefinitely.
Parameters Adjustable Through Special Menu	Probe type Delay I Delay III Delay II Stage 1 gain Stage 2 gain AGC limit Pulser repitition rate Number of shots Receiver phase select Interface phase select TGC level
Standard Outputs:	RF (BNC connector)

4.0 Specifications

System Timing	Pulser fire Delay I Delay II Delay III Main receiver detected video Contact time window Interface to first backwall time window Multiecho time window Logic level (TTL) alarm
Standard Outputs:	Open drain alarm (sink 50 mA max) Ground + 5V reference @ 25 mA max
Interfaces:	Interfaces will be able to access and control all normal and special menu control functions. All displayed information can be read through the interface port.
Transducer Connector:	BNC (or LEMO)
Operating Temperature Range:	14° F to 122° F -10° C to 50° C
Size:	11.5" x 7.25" x 3.0" 292 mm x 184 mm x 76 mm
Weight (with batteries)	4.5 lbs. (2 kg.)

Instrument specifications subject to change without prior notice.

4.2 CL304 Probe Specifications

Model	Designation	Frequency	Contact Diameter	Measuring Range (in steel)
Alpha 2 DFR	Standard Delay Line Probe	15 MHz.	.3 in 7.6 mm	with .375" delay .007-.700 in .18-17.8 mm with .500" delay .010-1.0 in .25-25 mm
Alpha 2A mini DFR	Thin Range Delay Line Probe	20 MHz.	.22 in 5.6 mm	.005-.200 in .15-5 mm
CA211A	Standard Contact Probe	5 MHz.	.75 in 19 mm	.060-15.0 in 1.5-380 mm
Alpha 2 Style F	Fingertip Contact Probe	10 MHz.	.375 in 9.5 mm	.060-10.0 in 1.5-250 mm
KBA 125	Thin Range Plastics Probe	20 MHz.	.3 in 7.6 mm	.010 in minimum * .25 mm minimum *

* NOTE: .010 inch (.25 mm) minimum measuring range in many plastics (not steel).

Probe specifications subject to change without prior notice.

Appendix A Rear Panel DB-15 Connector: System Timing Output Signals

PIN #	SIGNAL	DESCRIPTION
1	Ground	Signal ground reference.
2	Ground	Signal ground reference.
3	Ground	Signal ground reference.
4	Ground	Signal ground reference.
5	Ground	Signal ground reference.
6	Ground	Signal ground reference.
7	Ground	Signal ground reference.
8	+ 5VDC	+5 volt DC reference signal @ 25mA maximum.
9	Pulser fire	A logic level pulse synchronous with the firing of the CL304 pulser (transmitter). The pulse fires on the trailing edge of the logic pulse.

PIN #	SIGNAL	DESCRIPTION
10 11 12	Select A Select B Select C	Inputs to select signal for output on PIN 15. Lo = ground, Hi = +5V or open.
13	Alarm 1	Open drain output that is active when the high/low set point alarm is violated. Used for warning lamp or relay to be activated when alarm is violated.
14	Alarm 2	A logic level alarm output which is low when the set point alarm is violated and high when the alarm is not violated.
15	Selected Signal	
	SELECT INPUT A (PIN 10) B (PIN 11) C (PIN 12)	
	LO HI HI	**Contact time window.** The time window pulse generated by the contact mode time window generator. This time window is between the beginning of pulser fire and the first echo seen after Delay II.

SELECT INPUT A PIN 10	SELECT INPUT B PIN 11	SELECT INPUT C PIN 12	DESCRIPTION
LO	LO	LO	**Delay I.** The programmable time delay used for main bang ringing blockout in delay mode measurements.
LO	HI	LO	**Delay II.** The programmable time delay used for main bang ringing blockout in contact mode measurements and for interface echo ringing blockout in delay mode measurements.
HI	LO	LO	**Main Video.** The output of the video detector in the receiver section of the CL304. This signal produces the timing windows used for thickness measurements.
HI	HI	LO	**Delay III.** The programmable time delay used to detect whether the probe is coupled. If no echoes have been detected within the Delay III time, then the probe is considered to be uncoupled.
LO	LO	HI	**Multi-echo Time.** The time window pulse generated for multi-echo measurements. The time window is between the first two echoes after Delay II is completed.

SELECT INPUT A PIN 10	SELECT INPUT B PIN 11	SELECT INPUT C PIN 12	DESCRIPTION
HI	LO	HI	**Interface to First Time Window.** The time window pulse generated by the interface to first time window generator. This time window is between the interface echo and the first echo seen after Delay II. To observe a signal on an oscilloscope connect one channel to the RF BNC connector and the second channel to PIN 15 (selected signal). The oscilloscope should be triggered from pulser fire (PIN 9). Ground the appropriate select inputs to select the desired signal. The System Timing Accessory Output Box is recommended for this application.

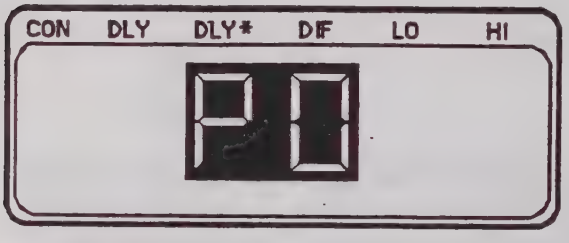


Figure 76

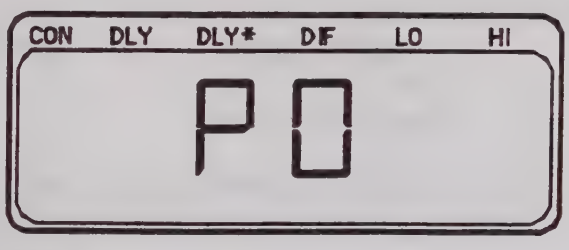


Figure 77

Appendix B New Probe Zero Block Procedure

The CL304 is supplied with a zero reference block for performing the necessary probe zero adjustment when contact style probes are used. The time of flight through this block is programmed into the CL304. Therefore, this is the only block that can be used for performing the probe zero adjustment. In the event that the supplied zero reference block becomes lost or damaged, it is possible to reprogram the CL304 to accept a new test block as a probe zero reference block. The new zero reference block must be steel and between 0.2 and 0.3 inches (5 mm to 7.5 mm) thick. Switch the instrument on and connect a *delay* type probe such as the standard Alpha 2 DFR. Make sure the CL304 is in the delay operating mode. (Press the **PROBE** key until the carat lights under **DLY** in the menu.) Press the **SHIFT** key followed by the **ZERO** key. The display will flash **P0**. Reference figure 76. Within 15 seconds, press the **CAL** and **ZERO** keys *simultaneously*, then release. The **P0** will stop flashing. Reference figure 77.

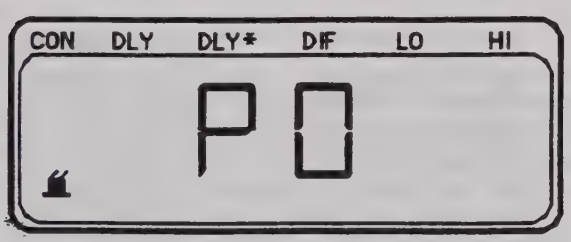


Figure 78

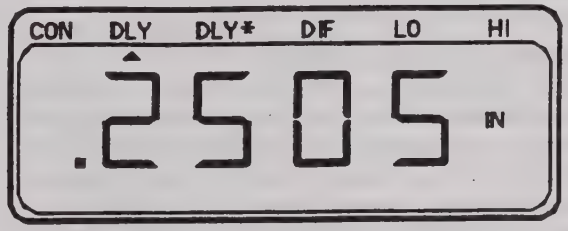


Figure 79

Couple the probe to the new zero reference block. The coupling indicator will light. Reference figure 78. Maintain steady coupling for approximately 3 seconds. The display will then revert to the previous operating mode, i.e. thickness, velocity, or time of flight measurement. Reference figure 79. The time of flight of the new zero reference block is now stored in the CL304's zero adjust storage register.

It should be noted that the new zero reference block must be used for all contact probe zero adjustments as the CL304 will no longer function correctly with the original probe zero reference block.

Appendix C Application Notes

The CL304 thickness gauge is easy to use and will produce reproducable precision measurements provided that it is used correctly and with an understanding of the factors that can affect measurement accuracy. The following paragraphs deal with some of the more common considerations encountered.

CALIBRATION

The accuracy of any measurement obtained with the CL304 is dependent on how well the instrument is calibrated. The importance of following the calibration procedures described in Section 2 cannot be overemphasized. The CL304 should be calibrated at the beginning of a measurement session and checked periodically during the session with test samples of known thickness. The gauge must also be recalibrated whenever the transducer or test material is changed. It is also recommended that the gauge be recalibrated if the thickness range to be measured changes significantly.

SURFACE CONDITION

The CL304 has been designed to provide optimum results when both the contact surface and the backwall are clean and smooth. If the contact surface is too rough, excess couplant can be trapped between the transducer and the test piece resulting in erroneous readings. If the backwall is rough or uneven, the ultrasonic pulses can become scattered or distorted, which can also lead to incorrect thickness readings. If it is necessary to test parts with rough surfaces, it is recommended that a gauge designed for this application, such as the Krautkramer Branson DME or DMX1, be used.

PART GEOMETRY

Part geometry can easily affect measurement accuracy. When testing parts with curved surfaces, such as a tube, it is very important that the transducer be placed on the center line of the part and that the transducer be held steady. Some practice may be necessary to develop the proper technique. As a general rule, as the radius of curvature of the test piece decreases, the diameter of the transducer used should also decrease in order to minimize transducer "rocking" problems.

Non-parallel surfaces, i.e. contact surface not parallel to the backwall, can also cause measurement errors. For critcal measurements on parts with non-parallel walls or curved parts it may be very helpful to view the echo waveforms on an oscilloscope.

COUPLING ERRORS

The couplant layer between the transducer and the test piece is part of the thickness measurement. To achieve maximum measurement accuracy, the couplant layer must be as thin as possible. This is achieved by using a couplant of low viscosity, using as little couplant as possible to obtain a stable reading, and by applying a firm even pressure on the transducer. As a general rule, larger diameter transducers require more pressure on the transducer to force the excess couplant from between the transducer and the test piece.

TEMPERATURE

Variations in temperature also affect measurement accuracy. Most materials expand when heated and contract when cooled. There can also be a change in the velocity of sound in a material when its temperature changes. For best accuracy, the CL304 should be calibrated on a calibration standard that is at the *same temperature as the parts to be measured.*

MATERIAL ACOUSTIC PROPERTIES

In addition to affecting measurement accuracy, the acoustic properties of materials can also affect the range of thicknesses that can be measured.

Attenuation. Many materials, especially lower density plastics and rubbers, rapidly attenuate ultrasonic signals. This can lead to reduced maximum thicknesses that can be measured, and, in severe cases, require adjustment to some special menu parameters (see section 3.0) in order to obtain reliable readings.

Scattering. Some materials are not homogeneous, i.e. not of uniform consistency throughout. Sound is scattered by the grain structure of some cast metals (stainless steels, iron, brass) and from the internal acoustic interfaces inherent in reinforced composite materials and fiberglas type materials. The scattering phenomena makes it difficult for the gauge to differentiate valid backwall echoes from spurious "scattered" echoes and can impact the ability of the instrument to measure the material accurately.

Velocity variations. A few materials are anisotropic with respect to the velocity of sound traveling through them, meaning the velocity of sound in the material varies depending on the *direction* of travel. Certain kinds of cast stainless steel and brass as well as some rolled metals exhibit this property. Caution should be exercised when measuring such materials. As previously noted, the velocity of sound in a material can also be affected by the temperature of the material. Plastics are most easily affected by temperature and care should be taken to maintain consistent temperature when testing plastic parts.

FLAWS

If, during testing, the CL304 suddenly reads a value that does not seem correct, e.g. much thinner than the apparent thickness of the part, the instrument may be reading a flaw or delamination in the test piece rather than the backwall. Reference Section 1.2 How the CL304 Measures Thickness. Such indications should be checked with an ultrasonic flaw detector.

TRANSDUCER SELECTION

A number of different types of transducers are available for use on the CL304: delay, contact, and immersion. Selection of the optimum transducer for a measurement application is based on the material to be tested and the geometry of the test piece. For best results, the highest frequency and smallest diameter transducer that will cover the required thickness range should be used. High frequency transducers have shorter pulse widths which improve the accuracy of the measurement. However, some applications, i.e. attenuative materials, may dictate that lower frequency transducers be used. Small diameter transducers are less likely to trap excess couplant between the transducer and the test piece, which also contributes to better measurement accuracy. Also, small diameter transducers provide better results on curved parts because of decreased transducer "rocking" problems.

Krautkramer Branson
Mifflin County Industrial Park
RD #4
Lewistown, PA 17044
(717) 242-0327
(717) 242-0331

Krautkramer Branson
New England Service Center
7 Wakeley Street
Seymour, CT 06483
(203) 881-1445
(203) 881-1447

Krautkramer Branson
Detroit Service Center
177 West Big Beaver
Troy, MI 48084
(313) 689-0444

Krautkramer Branson
Cincinnati Service Center
11503 Springfield Pike
Suite #6
Cincinnati, OH 45246
(513) 772-4745

Krautkramer Branson
6924 Canby Street
Suite 102
Reseda, CA 91335
(818) 705-3295

www.manualsplus.com
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